Perkins
WORKSHOP MANUAL

3.152, D3.152 Series

Perkins
Engines

workshop manual for 3.152 & D3.152 diesel engines

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This publication is written for world wide use. In territories where legal requirements govern smoke emission, noise, safety factors, etc., then all instructions, data and dimensions given must be applied in such a way that, after servicing (preventive maintenance) or repairing an engine, it does not contravene the local regulations when in use.

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In addition to the above, there are Perkins Distributors in the majority of countries. For further details, apply to Perkins Engines Ltd., Peterborough, or to one of the above companies.

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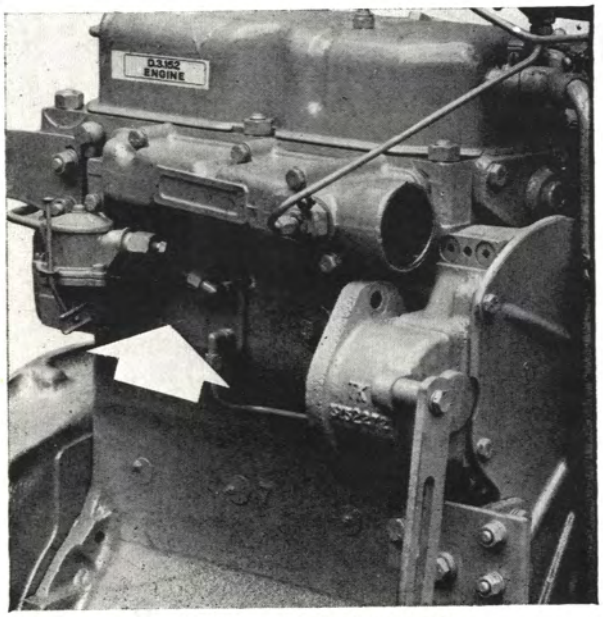
Engine No. Location



Location of Engine Number.

The engine number is stamped on the top right hand side of the cylinder block, as shown in the illustration. This number should be quoted when requesting information or ordering Parts.

A typical number is CD20166U510123D.

FOREWORD

This manual is designed to be of assistance to all personnel concerned with the maintenance and overhaul of the Perkins Diesel Engine. It presents a complete and detailed description of the Engine, together with precise instructions on servicing and overhaul procedure also a schedule covering manufacturing data and dimensions which should be closely followed when overhauling any part of the Engine to the Manufacturers standards.

The manual has been compiled for use in conjunction with normal workshop practice. Mention of certain accepted practices, therefore, has been purposely omitted in order to avoid repetition.

Reference to renewing joints and cleaning off joint faces, has to a great extent been omitted from the text, it being understood that this will be carried out where applicable.

Similarly, it is understood that in re-assembly and inspection, all parts are to be thoroughly cleaned and where present, burrs and scale are to be removed.

It follows that any open ports of high precision components, e.g. fuel injection equipment, exposed by dismantling, will be blanked off until re-assembly, to prevent the ingress of foreign matter.

When fitting setscrews or studs into holes which are tapped through into the interior of the engine, a suitable sealant should be used.

Some setscrews may already have sealant coated threads. These can be identified by the colour of the threads which will be red or blue, etc. Ensure that where these setscrews are fitted, the holes do not have sharp edges as this could remove the sealant.

Unless specified otherwise, the information given applies to both 3.152 and D3.152 engines. Where the information given differs for engines built for Massey Ferguson applications (A3.152 and AD3.152 engines), reference is made in the text.

3.152 and D3.152 have a left hand rotation when viewed from the rear. Throughout this manual, whenever the "left" or "right" hand side of the engine is referred to, it is that side of the engine when viewed from the flywheel end.

Division of the manual into sections is intended to simplify the task of locating any specific information contained therein.

Page and illustration numbers are not accumulative, but start afresh with each section, preceded by the appropriate reference letter for that section, for example, Page C.2. and Figure C.3. are page and illustration numbers respectively, under Section C.

Effective maintenance can only be carried out if the personnel concerned are fully conversant with the various components of the engine. Before maintenance operations are commenced, therefore, this manual should be carefully studied, and it should at all time be kept where it will be needed in the workshop.

Certain operations described herein require the use of special Tools. These tools are available from Perkins Distributors or

Messrs. V. L. Churchill & Co. Ltd.

Full details are given in the appendix.

A School of Instruction is maintained at Peterborough, where the staff employed by Distributors and Operators of Perkins powered applications are given instructions on Diesel engine maintenance, with particular regard to the special characteristics of Perkins Engines.

In the event of difficulty, Distributors are recommended to communicate with one of the Companies given on Page 2.

ENGINE PARTS

Whenever parts are ordered for Perkins Engines it is essential that the fullest information possible is given, always quote the engine number, type of application, and where possible the part number and description.

SAFETY PRECAUTIONS

THESE SAFETY PRECAUTIONS ARE IMPORTANT. Reference must also be made to the local regulations in the country of operation.

Do not change the specification of the engine.

Do not use these engines in marine applications unless specially manufactured for this purpose.

Do not smoke when you put fuel in the tank.

Clean away any fuel which has fallen and move material which has fuel contamination to a safe place.

Do not put fuel in the tank during engine operation (unless really necessary).

Never clean, lubricate or adjust the engine during operation (unless you have had the correct training when extreme caution must be used to prevent injury).

Do not make any adjustments you do not understand.

Ensure that the engine is not in a position to cause a concentration of toxic emissions.

Persons in the area must be kept well clear during engine and equipment operation.

Do not permit loose clothing or long hair near parts which move.

Keep away from parts which turn during operation. Note that fans and water pump/alternator drive belts can not be seen clearly while the engine is run.

Do not run engine with any safety guards removed.

Do not remove the radiator cap or header tank filler cap while the engine is hot and the coolant is under pressure as dangerous hot coolant can be discharged.

Do not use salt water in the radiator cooling system or the closed circuit cooling system of marine engines or any other coolant which can cause corrosion.

Keep sparks or fire away from batteries (especially while during charge) or combustion can occur. The battery fluid can burn and is also dangerous to the skin and especially the eyes.

Disconnect the battery terminals before you make a repair to the electrical system.

Only one person must be in control of the engine.

Ensure the engine is only operated from the control panel or operators position.

If your skin comes into contact with high pressure fuel, get medical assistance immediately.

Diesel fuel can cause skin damage to some persons. Use protection on the hands (gloves or special skin protection solutions).

Ensure that the transmission drive control is in "Out of Drive" position before the engine is started.

Do not move mobile equipment unless the brakes are in good condition.

With marine engines, extreme care must be taken if emergency repairs have to be made at sea or in adverse conditions.

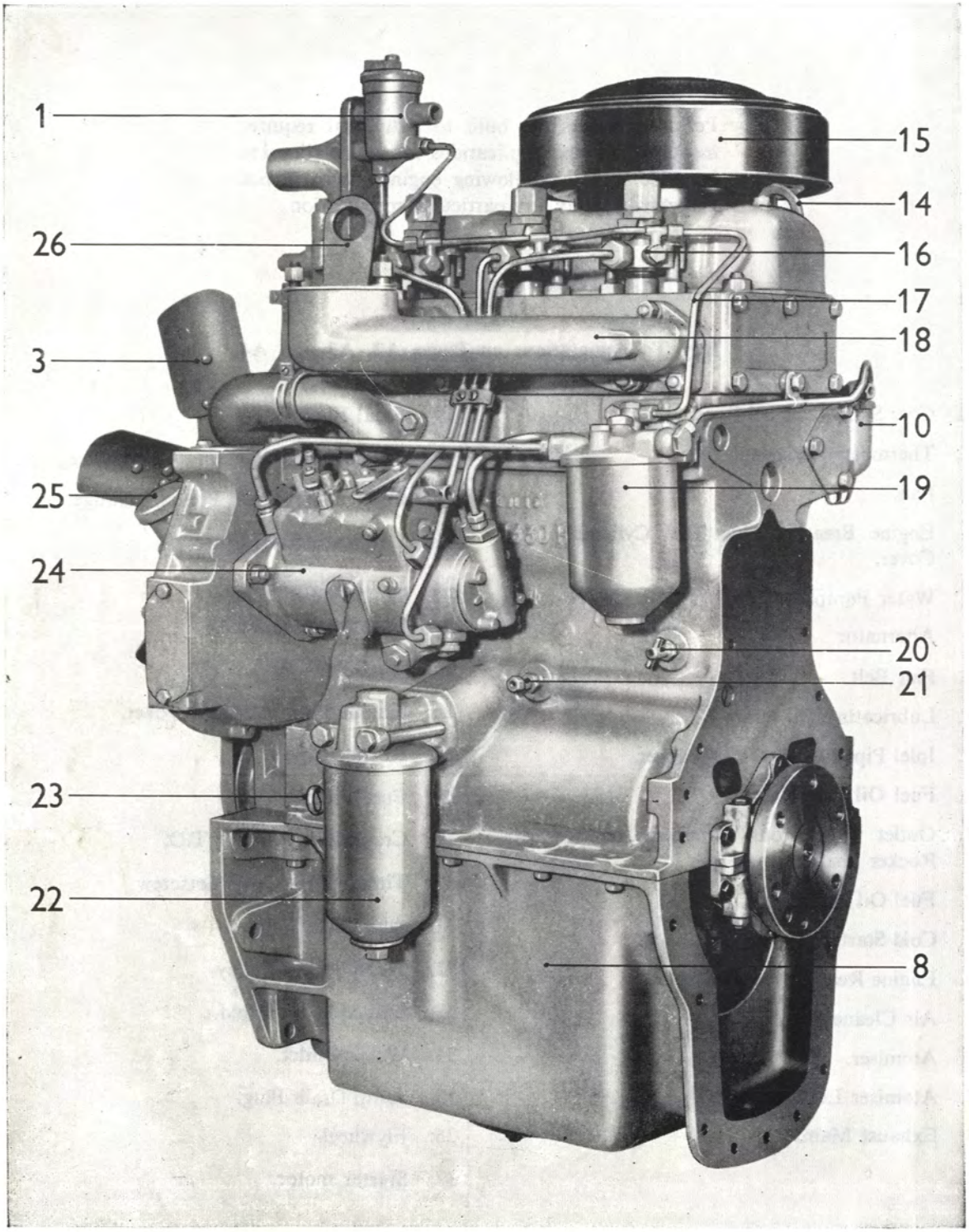
Fit only correct Perkins Parts.

SECTION A
Engine Views

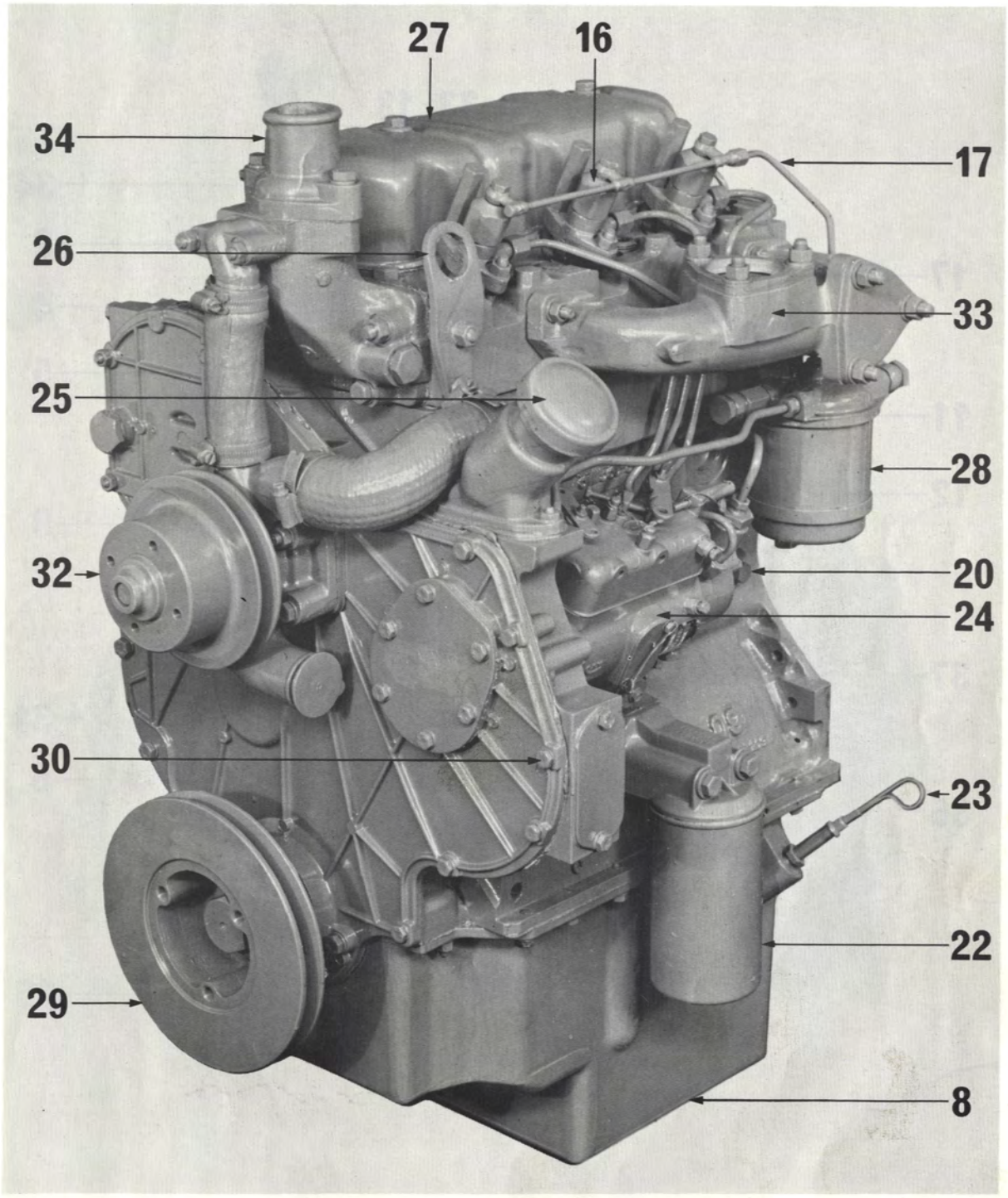
Perkins Engines are built to individual requirements to suit the applications for which they are intended and the following engine views do not necessarily typify any particular specification.

Key To Annotations on Pages A2, A3 and A4

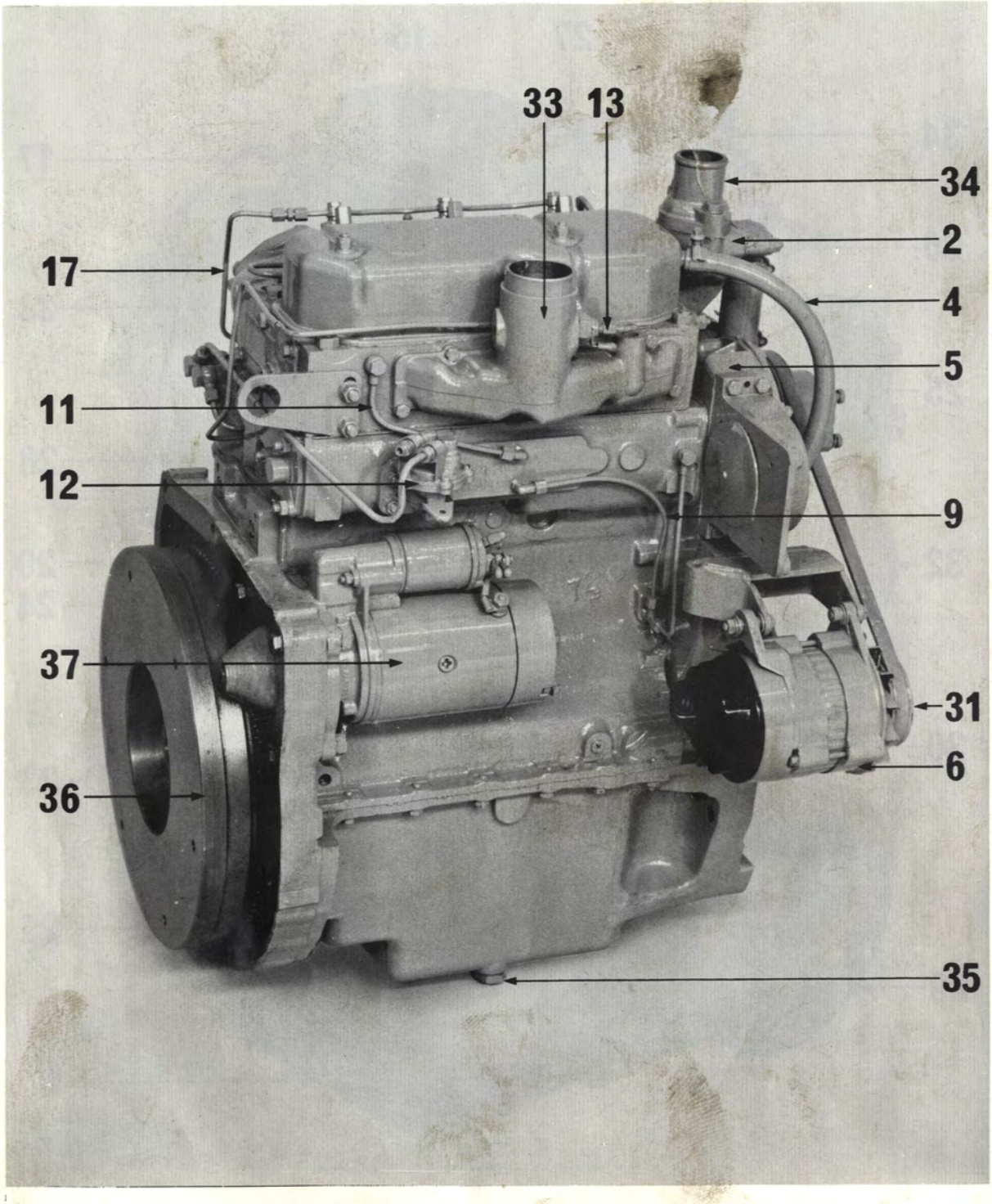
1. Cold Start Aid Fuel Reservoir.
2. Thermostat Housing.
3. Fan.
4. Engine Breather Pipe from Cylinder Head Cover.
5. Water Pump.
6. Alternator
7. Fan Belt.
8. Lubricating Oil Sump.
9. Inlet Pipe to Camshaft Reducer.
10. Fuel Oil Pre-Filter.
11. Outlet Pipe from Camshaft Reducer to Rocker Shaft.
12. Fuel Oil Lift Pump.
13. Cold Start Aid.
14. Engine Rear Lifting Bracket.
15. Air Cleaner.
16. Atomiser.
17. Atomiser Leak-off Pipe.
18. Exhaust Manifold.
19. Final Fuel Filter.
20. Cylinder Block Drain Tap or plug.
21. Connection for Oil Pressure Gauge.
22. Lubricating Oil Filter.
23. Sump Dipstick.
24. Fuel Injection Pump.
25. Oil Filler Cap.
26. Engine Front Lifting Bracket.
27. Rocker Cover.
28. Fuel Filter.
29. Crankshaft Pulley/P.T.O.
30. Timing Case Cover Setscrew.
31. Alternator Pulley
32. Water Pump Pulley.
33. Induction Manifold.
34. Water Outlet.
35. Sump Drain Plug.
36. Flywheel.
37. Starter motor.



View of Left Hand Side of 3.152 Industrial Engine



View of Left Hand Side of D3.152 Engine



View of Right Hand Side of D3.152 Engine

SECTION B
Technical Data

Engine Data

Type — 3.152	Three Cylinder, Four Stroke, Indirect Injection
Type — D3.152	Three Cylinder, Four Stroke, Direct Injection
Bore	3.6 in (91,44 mm) Nominal
Stroke	5 in (127 mm)
Cubic Capacity	152 in³ (2,5 litres)
Compression Ratio — 3.152	17.4 : 1
Compression Ratio — D3.152	18.5 : 1
Compression Ratio — Up-rated AD3.152 ...	16.5 : 1
Firing Order	1, 2, 3
Valve Clearance	0.012 in (0,30 mm) Cold
Lubricating Oil Pressure	30/60 lbf/in² (2,1/4,2 kgf/cm²) — 207/414 kN/m² at maximum engine speed and normal operating temperature.

Recommended Torque Tensions

Cylinder Head Nuts	60 lbf ft (8,3 kgf m) — 81 Nm
Cylinder Head Nuts/Setscrews	70 lbf ft (9,68 kgf m) — 95 Nm
Con. Rod Nuts (non-plated, self locking) ...	70 lbf ft (9,68 kgf m) — 95 Nm
Con. Rod Nuts (cadmium plated)	45 lbf ft (6,22 kgf m) — 61 Nm
Con. Rod Nuts (Phosphated)	60 lbf ft (8,3 kgf m) — 81 Nm
Main Bearing Setscrews	110 lbf ft (15,0 kgf m) — 150 Nm
Idler Gear Retaining Setscrew	50 lbf ft (6,9 kgf m) — 68 Nm
Camshaft Gear Retaining Setscrews	21 lbf ft (2,9 kgf m) — 28 Nm
Balance Weight Setscrews	55 lbf ft (7,6 kgf m) — 75 Nm
Flywheel Setscrews	78 lbf ft (10,8 kgf m) — 106 Nm
Atomiser Securing Nuts	12 lbf ft (1,7 kgf m) — 16 Nm
Crankshaft Pulley Retaining Setscrew — with $\frac{3}{16}$ in (4,8 mm) thick washer	105 lbf ft (14,5 kgf m) — 142 Nm
Crankshaft Pulley Retaining Setscrew — with 0.35 in (8,9 mm) thick washer	240 lbf ft (33,2 kgf m) — 325 Nm
Dynamo Pulley Nut ($\frac{7}{16}$ in)	20 lbf ft (2,7 kgf m) — 27 Nm
Dynamo Pulley Nut ($\frac{5}{8}$ in)	25 lbf ft (3,5 kgf m) — 34 Nm
Alternator Pulley Nut ($\frac{7}{16}$ in)	30 lbf ft (4,1 kgf m) — 41 Nm
Alternator Pulley Nut ($\frac{9}{16}$ in)	30 lbf ft (4,1 kgf m) — 41 Nm
Alternator Pulley Nut ($\frac{5}{8}$ in)	42 lbf ft (5,8 kgf m) — 51 Nm
High Pressure Fuel Pipe Nuts	15 lbf ft (2,1 kgf m) — 20 Nm
Thermostart	10 lbf ft (1,4 kgf m) — 13,6 Nm
Thermostart Adaptor (where fitted)	10 lbf ft (1,4 kgf m) — 13,6 Nm

Shim washers and tab washers fitted under the main bearing setscrews have been deleted and may be discarded in service.

Where self-locking nuts are employed and have for any reason been removed, they must be replaced by new ones.

TECHNICAL DATA—B.2

Engine Ratings

3.152

Maximum Gross Output	45 bhp (33.5 kW) at 2,500 rev/min
Maximum Torque	115 lbf ft (15.9 kgf m or 155 Nm) at 1,350 rev/min

D3.152

Maximum Gross Output	49 bhp (36 kW) at 2,500 rev/min
Maximum Torque	118 lbf ft (16,3 kgf m or 160 Nm) at 1,400 rev/min

The above quoted ratings are maximum under BS.AU 141a : 1971 conditions and can vary according to application. For further information apply to the Technical Services Department or one of the Perkins Companies listed on Page 2.

De-Rating for Altitude

Where engines are called upon to operate in rarefied atmospheres occasioned by altitude, such engines should be de-rated.

The following table is given as a general guide, which may be applied on a percentage basis, where specific figures for a particular engine rating are not available.

Altitude	Maximum fuel delivery de-rating*
0 — 2,000 feet (600 metre)	No change
2,000 — 4,000 feet (1,200 metre)	6%
4,000 — 6,000 feet (1,800 metre)	12%
6,000 — 8,000 feet (2,400 metre)	18%
8,000 — 10,000 feet (3,000 metre)	24%
10,000 — 12,000 feet (3,600 metre)	30%

*Measured at setting speed given in pump setting code.

Any necessary adjustments in this respect to the fuel pump should be carried out by the C.A.V. dealer for the territory concerned.

For further information apply to the Technical Services Department or one of the Perkins Companies listed on Page 2.

Approximate Dry Weights

Bare engine with accessories but no flywheel or backplate :—

3.152	445 lb (202 kg)
D3.152	450 lb (204 kg)

Typical Dry Installed Weight :—

Agricultural Engine	640 lb (290 kg)
Industrial Engine	685 lb (310 kg)

Manufacturing Data and Dimensions

The following data of clearances and tolerances are given as a guide for personnel engaged upon major overhauls and the figures are those used in the factory for production purposes. Unless specified otherwise the information applies to both 3.152 and D3.152 engines.

Cylinder Block

Height of Cylinder Block between Top and Bottom Faces	13.7405/13.7435 in (349,01/349,08 mm)
Parent Bore Dia. for Cylinder Liner	3.6875/3.6885 in (93,66/93,69 mm)
Depth of Recess for Liner Flange (Chrome Liners)	0.046/0.049 in (1,17/1,24 mm)
Depth of Recess for Liner Flange (Cast Iron Liners)	0.148/0.152 in (3,76/3,86 mm)
Dia. of Recess for Liner Flange (Chrome Liners)	3.820/3.825 in (97,03/97,16 mm)
Dia. of Recess for Liner Flange (Cast Iron Liners)	3.820/3.825 in (97,03/97,16 mm)
Main Bearing Parent Bore Dia.	2.9165/2.9175 in (74,08/74,10 mm)
Parent Bore for No. 1 Camshaft Bearing Bush (where fitted)	2.0000/2.0012 in (50,80/50,83 mm)
Internal Dia. of No. 1 Camshaft Bearing Bush (where fitted)	1.872/1.874 in (47,55/47,60 mm)
Camshaft Bore Dia. — No. 1	1.874/1.877 in (47,60/47,68 mm)
Camshaft Bore Dia. — No. 2	1.864/1.867 in (47,35/47,42 mm)
Camshaft Bore Dia. — No. 3	1.844/1.847 in (46,84/46,91 mm)

Cylinder Liners — Chromard

Type	Dry — Transition Fit — Pre-finished
Outside Dia. of Liner	3.6875/3.6885 in (93,66/93,69 mm)
Transition Fit of Liner in Block	0.001/0.001 in (0,03/0,03 mm)
Inside Dia. of Liner in Block	3.6015/3.6025 in (91,48/91,50 mm)
Flange Thickness	0.042/0.045 in (1,07/1,14 mm)
Flange Dia.	3.805/3.810 in (96,65/96,77 mm)
Depth of Liner Flange Below Top Face of Cylinder Block	0.001/0.007 in (0,03/0,18 mm)

TECHNICAL DATA—B.4

Cylinder Liners — Cast Iron

Type — Production Liner	Dry — Interference Fit
— Service Liner	Dry — Pre-finished — Transition Fit
Outside Dia. of Production Liner	3.6895/3.6905 in (93,71/93,74 mm)
Outside Dia. of Service Liner	3.6875/3.6885 in (93,66/93,69 mm)
Interference Fit of Production Liner in Block ...	0.001/0.003 in (0,03/0,08 mm)
Transition Fit of Service Liner in Block ...	0.001/0.001 in (0,03/0,03 mm)
Inside Dia. of Finished Production Liner in Block	3.6015/3.6025 in (91,48/91,50 mm)
Inside Dia. of Service Liner in Block	3.6025/3.6035 in (91,50/91,53 mm)
Outside Dia. of Liner Flange	3.803/3.808 in (96,60/96,72 mm)
Flange Thickness	0.148/0.150 in (3,76/3,81 mm)
Depth of Liner Flange relative to Top Face of Cylinder Block	+0.004/−0.004 in (+0,10/−0,10 mm)
Maximum Bore Wear (new liner needed) ...	0.007 in (0,178 mm)

Pistons — 3.152

Type	Flat Topped
Piston Height in relation to Cylinder Block Top Face	0.000/0.005 in (0,00/0,13 mm) **BELOW**
Bore Dia. for Gudgeon Pin	1.2499/1.2501 in (31,747/31,753 mm)
Top and 2nd Ring Groove Width	0.0957/0.0967 in (2,43/2,46 mm)
3rd Ring Groove Width	0.127/0.128 in (3,23/3,25 mm)
4th and 5th Ring Groove Width	0.252/0.253 in (6,40/6,43 mm)
Maximum Top Ring Clearance (with new ring fitted)	0.007 in (0,178 mm)

Pistons — D3.152

Type	Toroidal Cavity in Crown
Piston Height in relation to Cylinder Block Top Face	0.004 in (0,10 mm) **ABOVE** to 0.001 in (0,03 mm) **BELOW**
Bore Dia. for Gudgeon Pin	1.2499/1.2501 in (31,747/31,753 mm)
Top and 2nd Ring Groove Width	0.0957/0.0967 in (2,43/2,46 mm)
3rd Ring Groove Width	0.127/0.128 in (3,23/3,25 mm)
4th (and 5th Ring) Groove Width	0.252/0.253 in (6,40/6,43 mm)
Maximum Top Ring Clearance (with new ring fitted)	0.007 in (0,178 mm)

Pistons — Up-rated AD3.152

Type	Semi-spherical Cavity in Crown
Piston Height in relation to Cylinder Block Top Face	0.001/0.006 in (0,03/0,15 mm) **BELOW**
Bore Dia. for Gudgeon Pin	1.2499/1.2501 in (31,747/31,753 mm)
Top, 2nd and 3rd Ring Groove Width	0.0957/0.0967 in (2,43/2,46 mm)
4th Ring Groove Width	0.1895/0.1905 in (4,81/4,84 mm)
Maximum Top Ring Clearance (with new ring fitted)	0.007 in (0,178 mm)

Ring Gaps

The ring gaps quoted below are for when checking in an unworn portion of the cylinder bore.

Piston Rings — 3.152 Engines with Chromard Liners

Top Compression	Parallel Faced
2nd Compression	Taper Faced
3rd Compression	Laminated Segment
4th and 5th Oil Control	Slotted Scraper
Top and 2nd Ring Width	0.0928/0.0938 in (2,36/2,38 mm)
Top and 2nd Ring Clearance in Groove ...	0.0019/0.0039 in (0,05/0,10 mm)
4th and 5th Ring Width	0.249/0.250 in (6,32/6,35 mm)
4th and 5th Ring Clearance	0.002/0.004 in 0,05/0,10 mm)
Ring Gap — Top, 2nd, 4th and 5th	0.011/0.024 in (0,28/0,61 mm)

Piston Rings — 3.152 Engines with Cast Iron Liners and D3.152 Engines Rated Up To 2,250 rev/min

Top Compression	Chrome Plated
2nd Compression	Parallel Faced
3rd Compression	Laminated Segment
4th Oil Control	Spring Loaded, Laminated Scraper
4th Oil Control — 3.152 engines rated above 2,250 rev/min	Slotted Scraper
5th Oil Control	Slotted Scraper
Top and 2nd Ring Width	0.0928/0.0938 in (2,36/2,38 mm)
Top and 2nd Ring Clearance in Groove ...	0.0019/0.0039 in (0,05/0,10 mm)
Slotted Scraper Ring Width	0.249/0.250 in (6,32/6,35 mm)
Slotted Scraper Ring Clearance in Groove ...	0.002/0.004 in (0,05/0,10 mm)
Ring Gap — Top	0.014/0.030 in (0,36/0,76 mm)
Ring Gap — 2nd and Slotted Scraper	0.011/0.027 in (0,28/0,69 mm)

A few applications using D3.152 engines rated up to 2,250 rev/min employ the ring layout given on Page B.6 for higher rated D3.152 engines. A fuel injection pump setting code (see pump data plate) beginning with TW50 or WW47E normally indicates this ring arrangement on D3.152 engines.

Piston Rings — D3.152 Engines Rated Above 2,250 rev/min

Top Compression	Chrome Plated
2nd Compression	Parallel Faced
3rd Compression	Internally Stepped
4th Oil Control	Chrome Faced, Coil Spring Loaded
Top and 2nd Ring Width	0.0928/0.0938 in (2,36/2,38 mm)
Top and 2nd Ring Clearance in Groove	0.0019/0.0039 in (0,05/0,10 mm)
3rd Ring Width	0.0927/0.0937 in (2,35/2,38 mm)
4th Ring Width	0.249/0.250 in (6,32/6,35 mm)
Ring Gap — Top and 4th	0.014/0.027 in (0,36/0,69 mm)
Ring Gap — 2nd and 3rd	0.011/0.024 in (0,28/0,61 mm)

Piston Rings — Up-rated AD3.152 Engines

Top Compression	Chrome Plated
2nd and 3rd Compression	Internally Stepped
4th Oil Control	Chrome Faced, Coil Spring Loaded
Top Ring Width	0.0928/0.0938 in (2,36/2,38 mm)
Top Ring Clearance in Groove	0.0019/0.0039 in (0,05/0,10 mm)
2nd and 3rd Ring Width	0.0927/0.0937 in (2,35/2,38 mm)
4th Ring Width	0.1860/0.1875 in (4,72/4,76 mm)
2nd and 3rd Ring Clearance in Groove	0.002/0.004 in (0,05/0,10 mm)
4th Ring Clearance in Groove	0.002/0.0045 in (0,05/0,11 mm)
Ring Gap — Top	0.014/0.027 in (0,36/0,69 mm)
Ring Gap — 2nd and 3rd	0.011/0.024 in (0,28/0,61 mm)
Ring Gap — 4th	0.010/0.029 in (0,25/0,74 mm)

Gudgeon Pins

Type	Fully Floating
Outside Dia. of Gudgeon Pin	1.24975/1.25000 in (31,744/31,750 mm)
Fit in Piston Boss	Transition
Clearance Fit in Small End Bush	0.0005/0.00175 in (0,01/0,04 mm)

Small End Bushes

Type	Steel Backed, Lead Bronze Lined
Outside Dia.	1.3785/1.3800 in (35,01/35,05 mm)
Length	1.048/1.058 in (26,62/26,87 mm)
Inside Dia. after Reaming	1.2505/1.2515 in (31,76/31,79 mm)

Connecting Rods

Type	"H" Section
Big End Parent Bore Dia.	2.3950/2.3955 in (60,83/60,85 mm)
Small End Parent Bore Dia.	1.37475/1.37620 in (34,92/34,96 mm)
Big End Width	1.5502/1.5525 in (39,38/39,43 mm)
Big End Side Clearance on Crankpin	0.0095/0.0198 in (0,24/0,50 mm)
Length Between Bore Centres (3.152)	8.999/9.001 in (228,57/228,63 mm)
Length Between Bore Centres (D3.152) ...	8.811/8.813 in (223,80/223,85 mm)

Connecting Rod Alignment

Large and small end bores must be square and parallel to each other within the limits of ±0.010 in (0,25 mm), measured 5 in (127 mm) each side of the axis of the rod on test mandrel as shown in Fig. B.1. With the small end bush fitted, the limit of ±0.010 in (0,25 mm) is reduced to ±0.0025 in (0,06 mm).

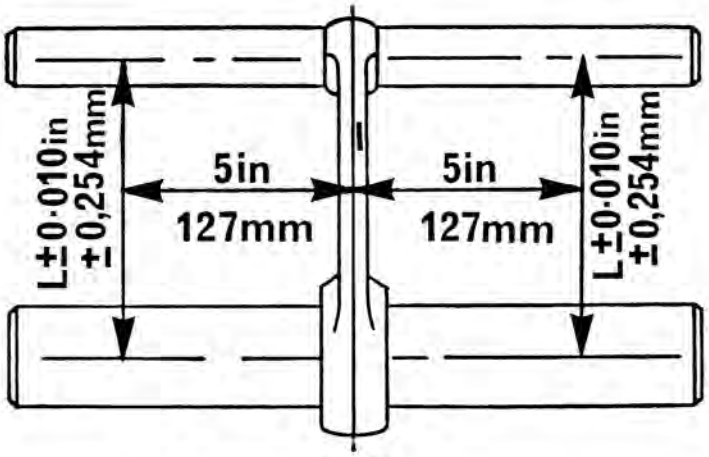


Fig. B1.

Connecting Rod Bearings

Type	Pre-finished, Steel Backed, Aluminium Tin Lined
Inside Dia.	2.2515/2.2525 in (57,19/57,21 mm)
Bearing Running Clearance	0.0023/0.0041 in (0,06/0,10 mm)

Crankshaft

Main Journal Dia.	2.7485/2.7493 in (69,81/69,83 mm)
Main Journal Length — Nos. 2 and 3	1.2147/1.2227 in (30,85/31,06 mm)
Main Journal Length — No. 4 (Rope Type Seal)	1.8742/1.8772 in (47,60/47,68 mm)
Main Journal Length — No. 4 (Lip Seal) ...	1.8427/1.8457 in (46,80/46,88 mm)
Main Journal Fillet Radii	0.0937/0.1094 in (2,38/2,78 mm)
Crankpin Dia.	2.2484/2.2492 in (57,11/57,13 mm)
Crankpin Length	1.562/1.570 in (39,67/39,88 mm)
Crankpin Fillet Radii	0.1562/0.1719 in (3,97/4,37 mm)
Surface Finish — All Pins and Journals ...	16 micro inches (0,4 microns) Maximum
Oil Seal Helix Depth — Rope Type Seal ...	0.004/0.008 in (0,10/0,20 mm)
Oil Seal Helix Width — Rope Type Seal ...	0.050/0.080 in (1,27/2,03 mm)
Crankshaft End Float	0.002/0.015 in (0,05/0,38 mm)
Regrind Undersizes — Main Journals and Pins ...	0.010 in (0,25 mm), 0.20 in (0,51 mm), 0.030 in (0,76 mm)
Crankshaft Main and Crankpin Journal maximum Wear and Ovality	0.0015 in (0,038 mm)

Crankshaft Thrust Washers

Type	Steel Backed, Aluminium Tin Faced
Position in Engine	Cylinder Block, Rear Main Bearing Housing
Thrust Washer Thickness — Standard	0,121/0.123 in (3,07/3,12 mm)
Thrust Washer Thickness — Oversize	0.1285/0.1305 in (3,26/3,31 mm)

Main Bearings

Type	Steel Backed, Aluminium Tin Lined
Inside Dia.	2.7510/2.7525 in (69,88/69.91 mm)
Main Bearing Running Clearance	0.0017/0.0040 in (0,04/0,10 mm)

Camshaft

No. 1 Journal Dia.	1.869/1.870 in (47,47/47,50 mm)
Running Clearance — With Bush	0.002/0.005 in (0,05/0,13 mm)
Running Clearance — No Bush	0.004/0.008 in (0,10/0,20 mm)
No. 2 Journal Dia.	1.859/1.860 in (47,22/47,24 mm)
Running Clearance	0.004/0.008 in (0,10/0,20 mm)
No. 3 Journal Dia.	1.839/1.840 in (46,71/46,74 mm)
Running Clearance	0.004/0.008 in (0,10/0,20 mm)
Cam Lift	0.311/0.314 in (7,90/7,98 mm)
Gear Spigot Dia.	1.9985/1.9995 in (50,76/50,79 mm)
Camshaft Journals Maximum Wear and Ovality (Service)	0.002 in (0,05 mm)

Cylinder Head

Depth	2.985/3.015 in (75,82/76,58 mm)
Permissable Cylinder Head Bow	Transverse 0.003 in (0,076 mm) max. Longitudinal 0.006 in (0,152 mm) max.
Skimming Allowance on Head Face — 3.152 ...	Head depth may be reduced to 2.980 in (75,69 mm) minimum
Skimming Allowance on Head Face — D3.152 ...	0.012 in (0,30 mm) maximum, providing nozzle protrusion does not exceed 0.184 in (4,67 mm) after skimming
Skimming Allowance on Head Face — Up-rated AD3.152	0.012 in (0,30 mm) maximum, providing nozzle protrusion does not exceed 0.179 in (4,55 mm) after skimming
Leak Test Pressure	30 lbf/in² (2,11 kgf/cm²) or 207 kN/m²
Valve Seat Angle — 3.152	45°
Valve Seat Angle — D3.152 prior to Engine No. CE - - - - - U584638F	45° or 35° depending upon application
Valve Seat Angle — D3.152 Commencing Engine No. CE - - - - - U584638F	35°
Tappet Bore in Cylinder Head	0.6245/0.62575 in (15,86/15,89 mm)
Valve Guide Bore in Cylinder Head	0.4995/0.5005 in (12,69/12,71 mm)

Valve Guides

Inside Dia.	0.3141/0.3155 in (7,98/8,01 mm)
Outside Dia.	0.5021/0.5026 in (12,75/12,77 mm)
Interference Fit of Guide in Cylinder Head ...	0.0016/0.0031 in (0,04/0,08 mm)
Overall Length	2.425/2.455 in (61,60/62,36 mm)
Guide Protrusion above Spring Seating Face ...	0.580/0.594 in (14,73/15,09 mm)

Inlet Valves

Valve Stem Dia.	0.311/0.312 in (7,90/7,92 mm)
Clearance Fit of Valve in Guide	0.0021/0.0045 in (0,05/0,11 mm)
Maximum Stem/Guide Clearance (Service) ...	0.006 in (0.152 mm)
Valve Face Angle — 3.152	45°
Valve Face Angle — D3.152 prior to Engine No. CE - - - - - U584638F	45° or 35° depending upon application
Valve Face Angle — D3.152 commencing Engine No. CE - - - - - U584638F	35°
Valve Head Depth below Cylinder Head Face — 3.152	0.066/0.080 in (1,68/2,03 mm)
— D3.152 with 45° Seats	0.059/0.074 in (1,50/1,89 mm)
— D3.152 with 35° Seats	0.054/0.064 in (1,32/1,63 mm)

Exhaust Valves

Valve Stem Dia.	0.311/0.312 in (7,90/7,92 mm)
Clearance Fit of Valve in Guide	0.0021/0.0045 in (0,05/0,11 mm)
Maximum Stem/Guide Clearance (Service) ...	0.0055 in (0,14 mm)
Valve Face Angle — 3.152	45°
Valve Face Angle — D3.152 prior to Engine No. CE - - - - - U584638F	45° or 35° depending upon application
Valve Face Angle — D3.152 commencing Engine No. CE - - - - - U584638F	35°
Valve Head Depth below Cylinder Head Face — 3.152	0.066/0.080 in (1,68/2,03 mm)
— D3.152 with 45° Seats	0.058/0.073 in (1,47/1,87 mm)
— D3.152 with 35° Seats	0.063/0.0755 in (1,60/1,92 mm)

Valve Springs

Free Length	1.783/1.803 in (45,29/45,80 mm)
Fitted Length	1.500 in (38,10 mm)
Load at Fitted Length	22.75 lb ± 2 lb (10,34 kg ± 0,90 kg)

Inner Valve Springs (Where Fitted)

Free Length	1.365/1.405 in (34,67/35,69 mm)
Fitted Length	1.1875 in (30,16 mm)
Load at Fitted Length	8.0 lb ± 1 lb (3,63 kg ± 0,45 kg)

Tappets

Outside Dia. of Shank	0.62225/0.62375 in (15,81/15,84 mm)
Clearance Fit in Cylinder Head	0.00075/0.00350 in (0,02/0,09 mm)

TECHNICAL DATA—B.10

Rocker Shaft

Outside Dia.	0.62225/0.62375 in (15,81/15,84 mm)

Rocker Levers

Bore Dia.	0.62450/0.62575 in (15,86/15,89 mm)
Clearance Fit on Rocker Shaft	0.00075/0.00350 in (0,02/0,09 mm)
Maximum Rocker Clearance on Shaft	0.005 in (0,13 mm)

Camshaft Gear

No. of Teeth	50
Gear Bore Dia.	1.9995/2.0010 in (50,79/50,83 mm)
Clearance Fit of Gear on Spigot	0.0000/0.0025 in (0,00/0,06 mm)

Idler Gear and Hub

No. of Teeth	90
Bore Dia. of Gear	2.1250/2.1266 in (53,98/54,02 mm)
Dia. of Hub	2.1230/2.1238 in (53,92/53,94 mm)
Clearance of Gear on Hub	0.0012/0.0036 in (0,03/0,09 mm)
Gear Width	1.3175/1.3225 in (33,47/33,59 mm)
Bearing Length of Hub	1.3275/1.3325 in (33,72/33,85 mm)
Gear End Float	0.005/0.015 in (0,13/0,38 mm)
Maximum Gear End Float (Service)	0.018 in (0,46 mm)

Crankshaft Gear

No. of Teeth	25
Dia. of Bore	1.4995/1.5010 in (38,09/38,13 mm)
Spigot Dia. of Crankshaft	1.5000/1.5005 in (38,10/38,11 mm)
Transition Fit of Gear on Crankshaft	0.001/0.001 in (0,03/0,03 mm)

Fuel Pump Gear

No. of Teeth	50
Dia. of Bore	1.750/1.751 in (44,45/44,48 mm)
Pump Spigot Dia.	1.7480/1.7488 in (44,40/44,42 mm)
Clearance Fit of Gear on Spigot	0.0012/0.003 in (0,03/0,08 mm)

Timing Gear Backlash

All Gears	0.003 in (0,08 mm) minimum

Lubricating Oil Pump Idler Gear

Inside Dia. of Gear Bore	0.750/0.751 in (19,05/19,08 mm)
Outside Dia of Bush	0.7520/0.7535 in (19,10/19,14 mm)
Interference Fit of Bush in Gear	0.0010/0.0035 in (0,03/0,09 mm)
Inside Dia. of Bush — Fitted	0.6562/0.6572 in (16,67/16,69 mm)
Dia. of Gear Shaft	0.6548/0.6553 in (16,63/16,64 mm)
Running Clearance of Gear on Shaft	0.0009/0.0024 in (0,02/0,06 mm)
Gear End Float	0.008/0.023 in (0,20/0,58 mm)

Lubricating Oil Pump Drive Gear

Internal Dia. of Gear Bore	0.4962/0.4972 in (12,60/12,63 mm)
Pump Drive Shaft Dia.	0.4990/0.4995 in (12,67/12,69 mm)
Interference Fit of Gear on Shaft	0.0018/0.0033 in (0,05/0,08 mm)

Lubricating Oil Pump Clearances

Pump Part Nos. : 41314026, 41314046 and 41314078

Inner Rotor to Outer Rotor	0.0005/0.0025 in (0,01/0,06 mm)
Inner Rotor End Clearance	0.0015/0.0030 in (0,04/0,08 mm)
Outer Rotor End Clearance	0.0005/0.0025 in (0,01/0,06 mm)
Outer Rotor to Pump Body	0.011/0.013 in (0,28/0,33 mm)

Pump Part Nos. : 41314043, 41314079 and 41314081

Inner Rotor to Outer Rotor	0.001/0.006 in (0,03/0,15 mm)
Inner and Outer Rotor End Clearance	0.001/0.005 in (0,03/0,13 mm)
Outer Rotor to Pump Body	0.0055/0.0100 in (0,14/0,25 mm)

Pump Part No. 41314124

Inner Rotor to Outer Rotor	0.0025/0.0045 in (0,06/0,11 mm)
Inner and Outer Rotor End Clearance	0.001/0.003 in (0,03/0,08 mm)
Outer Rotor to Pump Body	0.010/0.012 in (0,25/0,30 mm)

Lubricating Oil Relief Valve

Dia. of Bore in Pump Body	0.5605/0.5625 in (14,24/14,29 mm)
Outside Dia. of Plunger	0.5585/0.5595 in (14,19/14,21 mm)
Clearance of Plunger in Bore	0.001/0.004 in (0,03/0,10 mm)
Pressure Setting	50/65 lbf/in² (3,52/4,57 kgf/cm²) or 345/448 kN/m²

Lubricating Oil Filter

Type of Filter	Full Flow
Element Type	Paper or Renewable Canister
By-pass Setting	8.0/12.0 lbf/in² (0,56/0,84 kgf/cm²) or 55/83 kN/m²

TECHNICAL DATA—B.12

Lubricating Oil Sump

Capacity for Agricultural Engines	
— To Full Mark	10.7 Imp. pints (6,1 litres) 6.4 U.S. quarts
— To Minimum Mark	7.7 Imp. pints (4,4 litres) 4.6 U.S. quarts
Capacity for Industrial Engines	
— To Full Mark	13.0 Imp. pints (7,4 litres) 7.8 U.S. quarts

The above figures are general and can vary according to application. Fill to "FULL" mark on dipstick.

Cooling System

Type	Thermo Syphon — Pump Assisted
Coolant Capacity — Engine Only	8.5 Imp. pints (4,8 litres) 5.1 U.S. quarts

Thermostat

Type	Bellows or Wax
Opening Temperature — Bellows Type ...	170/179°F (77/82°C)
— Wax Type	177/183°F (81/84°C)
Fully Open Temperature — Bellows Type ...	199°F (93°C)
— Wax Type ...	208°F (98°C)

Direct Cooled Marine Engines

Type	Wax
Opening Temperature	109°F (43°C)
Fully Open Temperature	131°F (55°C)

Water Pump

Type	Centrifugal
Pulley Bore Dia.	0.6239/0.6247 in (15,85/15,87 mm)
Shaft Dia.	0.6262/0.6267 in (15,91/15,92 mm)
Interference Fit of Pulley on Shaft	0.0015/0.0028 in (0,04/0,07 mm)
Impeller Bore Dia.	0.6250/0.6257 in (15,88/15,89 mm)
Shaft Dia.	0.6262/0.6267 in (15,91/15,92 mm)
Interference Fit of Impeller on Shaft	0.0005/0.0017 in (0,01/0,04 mm)
Clearance between Impeller Blades and Body ...	0.010/0.020 in (0,25/0,51 mm)

Approved Fuel Oil Specifications

United Kingdom	BS.2869 : 1967 — Class A1 and A2.
United States	A.S.T.M/D.975 — 66T — Nos. 1D or 2-D. VV — F — 800a : Grades DF-A, DF-1 or DF-2.
Germany	DIN-51601 (1967).
France	(J.O. 14/9/57) Gas Oil or Fuel Domestique.
Italy	CUNA — Gas Oil NC-630-01 (1957).
India	IS : 1460/1968 — Grade Special or Grade A.
Sweden	SIS. 15 54 32 (1969).
Switzerland	Federal Military Specification 9140-335-1404 (1965).

Fuel oils available in territories other than those listed above which are to an equivalent specification may be used.

Fuel Lift Pump

Type	A C Delco
Method of Drive	Eccentric on Camshaft
Static Pressure (No Delivery)	6.0/10.0 lbf/in² (0.4/0.7 kgf/cm²) — 41/69 kN m⁻²

Fuel Injection Pump

Make	C A V
Type	D P A
Pump Rotation	Clockwise (from drive end)
Timing Letter	E
No. 1 Outlet	W or Z

Engine Checking and Fuel Pump Marking Angles, Static Timing

The correct marking angles and static timing can be found by reference to the prefix letters and figures of the setting code adjacent to the word "Set" on the fuel pump identification plate. Engine checking and fuel pump marking angles are for use with timing tool MS67B and adaptor PD67B-1.

Prefix Letters	Engine Checking Angle (Degrees) (with engine at TDC Compression)	Fuel pump Marking Angle (Degrees)	Static Timing (BTDC—Degrees)	Piston Displacement	
3.152				in	mm
LW45	32	40	16	0.124	3,15
LW49	32	40	16	0.124	3,15
LW51	29	38	18	0.155	3,94
LW52	29	38	18	0.155	3,94
LW58	29	40	22	0.230	5,84
LW59	29	40	22	0.230	5,84
PW43	30	38	16	0.124	3,15
PW44	30	38	16	0.124	3,15
PW50	29	38	18	0.155	3,94
D3.152					
MW47E	25	37	24	0.270	6,86
MW49	25	37	24	0.270	6,86
MW53E	25	37	24	0.270	6,86
MW57	25	37	24	0.270	6,86
RW50	25	37	24	0.270	6,86
RW52	25	37	24	0.270	6,86
RW54	25	37	24	0.270	6,86
SW46	25	37	24	0.270	6,86
*SW46	22¼	37	29½	0.411	10,43
SW46L	22¼	37	29½	0.411	10,43
SW48	24	37	26	0.315	8,00
SW52	25	37	24	0.270	6,86
SW57	25	37	24	0.270	6,86
SW58	25	37	24	0.270	6,86
TW48E	27	37	20	0.192	4,88
TW50	26	37	22	0.230	5,84
WW	27	35	16	0.124	3,15
WW47E	27	35	16	0.124	3,15
WW48	27	35	16	0.124	3,15
WW49L	25	35	20	0.192	4,88

*Lincoln Electric Welding Sets

TECHNICAL DATA—B.14

Atomisers

	Code Letters	Holder (C.A.V.)	Nozzle (C.A.V.)	Setting Pressure atm (kgf/cm²)	Working Pressure atm (kgf/cm²)
3.152 Engines					
	DD	BKB35S5258	BDL110S6133	125 (129)	120 (124)
	DE	BKB35S5258	BDL110S6267	125 (129)	120 (124)
	GC	BKB35SD5259	BDL110S6709	185 (191)	170 (176)
D3.152 Engines					
	BV	BKBL67SD5151	BDLL150S6513	185 (191)	170 (176)
	CR	BKBL67S5151	BDLL150S6513	185 (191)	170 (176)
	CS	BKBL67SD5151	BDLL150S6554	185 (191)	170 (176)
	DF	BKBL67S5151	BDLL150S6558	175 (181)	170 (176)
	DN	BKBL67S5299	BDLL150S6554	185 (191)	170 (176)
	EE	BKBL67S5299	BDLL150S6602	190 (181)	175 (181)
	FS*	BKBL67S5299	BDLL150S6674	185 (191)	170 (176)
	GM	BKBL67S5299	BDLL150S6743	185 (191)	175 (181)
	GW	BKB35SD5258	BDLL110S6709	185 (191)	170 (176)
	UB	BKBL67S5151	BDLL150S6372	185 (191)	170 (176)

*Where FS atomisers are serviced, they should be converted to DN type by fitting the appropriate nozzle.

Dynamo

Make	Lucas
Type	C40A
Maximum Output	11 amps

Alternator

	Lucas	Perkins
Make		
Type	15, 16, 17, 18 or 23 ACR	LR135 or LR150
Maximum Output (Hot)	15 ACR — 28A	LR135 - 35A LR150 - 50A
	16 ACR — 34A	
	17 ACR — 36A	
	17 ACR (De-rated) — 25A	
	18 ACR — 45A	
	23 ACR — 55A	
	A115/45 — 45A	

Starter Motor

	Lucas	Perkins
Make		
Type	2M 113 or M45G	S12 - 84 or S12 - 85
No. of Teeth on Pinion	10 or 11	10 or 11
Starter Cable Resistance	0.0017 ohms maximum	0.0017 ohms maximum

Note : The above electrical data is general and can vary with individual applications.

SECTION C
Operating and Maintenance

Preparation for Starting

Check the radiator water level.

Check the engine sump oil level.

See that there is fuel oil in the tank.

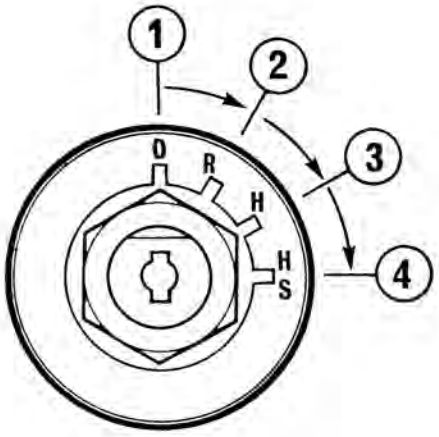
Check that the starter battery is fully charged and that all electrical connections are properly made and all circuits in order.

Starting the Engine

If the engine is warm, turn starter switch in a clockwise direction to the "HS" position (see Fig. C.1).

As soon as the engine starts, release the switch to the "R" position.

Be sure that the starter pinion and engine have stopped rotating before re-engaging the starter motor, otherwise damage may result.



C.1

1. Off Position.
2. Run Position.
3. Heat Position.
4. Heat and Start Position

If weather is cold, turn starter switch to the "H" position (see Fig. C.1) and hold it there for fifteen to twenty seconds.

Then turn the starter switch to the "HS" position thereby engaging the starter motor.

If the engine does not start after twenty seconds, return the switch to the "H" position for ten seconds and then re-engage the starter motor by switching to the "HS" position.

As soon as the engine starts, release the switch to the "R" position.

Earlier Heat Start Switch

The cold start switch supplied with earlier engines is shown in Fig. C.2.

With this type of switch, starting a warm engine is effected by turning the switch in a clockwise direction to the "S" position.

In cold weather, the switch should be turned to the "H" position for fifteen to twenty seconds and then to the "HS" position in order to engage the starter motor.

As soon as the engine starts, the switch should be returned to the "O" position.

Where this type of switch is used, it was sometimes customary to have a separate switch for the electrical circuits and this should be turned on before starting the engine and turned off after stopping the engine.

Starting the Engine (Alternative Method)

With some engines, a different starter switch may be found and the cold start aid operated by means of a separate push button switch.

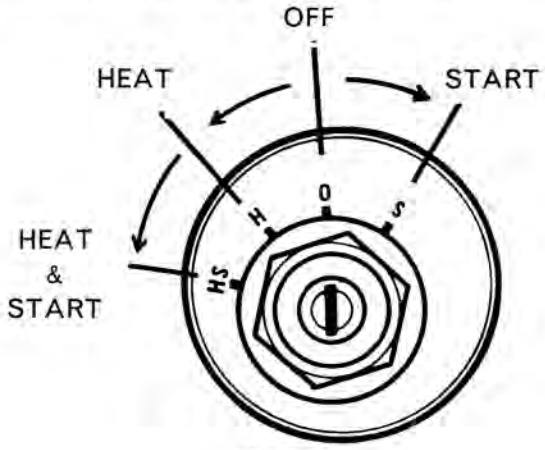


Fig. C.2

The cold starting procedure is however the same, i.e.,

Switch on by turning the starter switch in a clockwise direction to the first position.

Press the heater button for fifteen to twenty seconds and then, with the heater button still pressed, turn the starter switch in a further clockwise direction to engage the starter motor. As soon as the engine starts, release both starter switch and heater button.

Cold Starting Aid

Referring to Fig. C.3 the cold start unit comprises a tubular valve body carried in a holder which screws into the inlet manifold, and surrounded by a heater coil, an extension of which forms an igniter coil. The valve body houses a needle, the stem of which holds a ball valve in position against its seating. The whole is surrounded by an open perforated shield. Fuel oil from the container enters through an adaptor.

When the unit is cold, the ball valve is held closed. On switching on the coil, the valve body is heated and expands, opening the ball valve and permitting the entry of fuel. The fuel is vapourised by the heat of the valve body and when the engine is cranked and air is drawn into the manifold, the vapour is ignited by the coil extension and continues to burn, thus heating the inlet air

When the coil is switched off, the flow of air in the manifold cools the valve body rapidly and the valve closes.

The cold start aid is a sealed unit and cannot be dismantled. If the unit ceases to function, it must be renewed.

To Stop the Engine

A spring loaded stop control is located near the engine controls and functions by cutting off the fuel at the fuel injection pump.

To operate, pull the knob and hold in this position until the engine ceases to rotate. Ensure that the control returns to the run position, otherwise difficulty may be experienced in re-starting the engine.

Turn start switch to the "O" position.

Some engines are stopped by the use of a solenoid, which is energised by pressing a button, probably marked "STOP", or it may be energised by sensing equipment which is fitted to some machines or it may be switch operated.

Things to Note

Always be sure that the starter pinion has stopped revolving before re-engaging the starter, otherwise the ring or pinion may be damaged.

Ensure that the electrical connection to the cold starting aid is correctly made.

Always ensure that, if a reservoir is used to feed fuel to the starting aid, it is fully primed and is not leaking. On later engines, the starting aid fuel feed is taken directly from the fuel filter.

In the event of difficult starting, check that fuel is reaching the cold starting aid in the induction manifold by unscrewing the inlet fuel connection. If fuel is reaching it satisfactorily, then it may be that the cold starting aid itself is not working correctly. This can be checked by removing the air cleaner and watching the cold starting aid whilst the equipment is used. When the starting switch is turned to the "heat" position, the element should become red hot, and on engagement of the starter motor, it should burst into flame.

3.152 and D3.152 engines are fitted with efficient cold starting equipment and no responsibility can be accepted for any damage caused by unauthorised starting aids.

Running-In

It is not necessary to gradually run-in a new or factory replacement engine and any prolonged light load running during the early life of the engine can in fact prove harmful to the bedding in of piston rings and liners.

Full load can be applied on a new or factory replacement engine as soon as the engine is used **provided that the engine coolant is first allowed to reach a temperature of 140°F (60°C).**

Flame-Proofed Engines

Engines arranged to conform with flame-proofing regulations are usually fitted with non-electric starting equipment. This is supplied by the manufacturer of the application and for starting instructions, reference should be made to the appropriate manufacturer's handbook

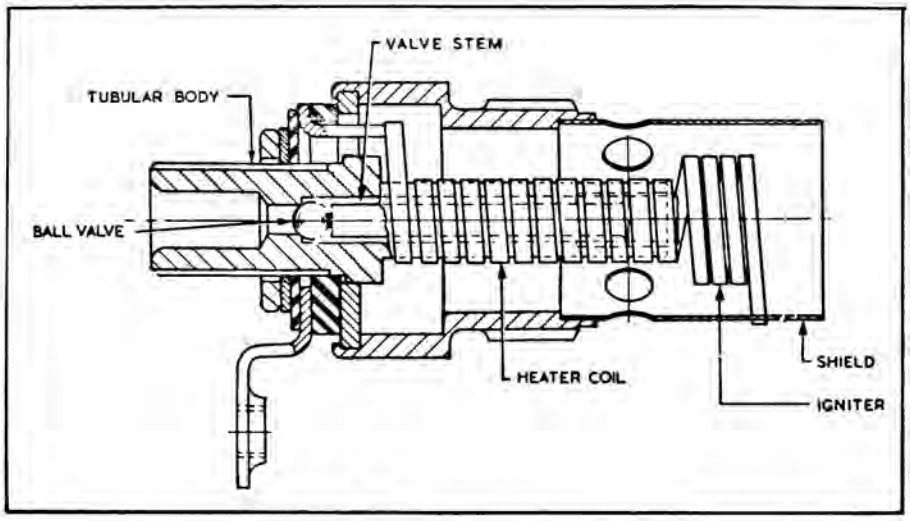


Fig. C.3

Preventive Maintenance

Operators of 3.152 and D3.152 engines are reminded that the following Preventive Maintenance are general in application : therefore the operator should compare the routine maintenance for his engine with the schedules specified by the manufacturer of the application to which the engine is fitted and where necessary adopt the shorter periods.

Whilst we have given specific periods for preventive maintenance, you should have due regard for the local regulations concerning your machine and ensure that the engine is operating within those regulations.

It is good engineering practice to check for water, fuel and lubricating oil leaks and the tightness of nuts, setscrews and hose clips at each servicing period.

It should be noted that the maintenance periods given are on the assumption that the fuel and lubricating oils are to the specifications given in this workshop manual.

Keep engine clean

DAILY OR EVERY 8 HOURS WHICHEVER OCCURS FIRST

Check level of coolant.

Check level of oil in sump.

Check oil pressures (where gauge fitted).

In extreme dust conditions, clean oil bath air cleaner and empty dust bowl on dry type air cleaner.

EVERY 250 HOURS OR FOUR MONTHS WHICHEVER OCCURS FIRST

Drain and renew lubricating oil. Refer to list of Approved Lubricating Oils in Appendix.

Renew lubricating oil filter element or canister.

Check drive belt tension.

Clean oil bath air cleaner.

Empty dust bowl on dry type air cleaner.

Clean lift pump pre-filter (where fitted).

Clean water trap.

Lubricate dynamo rear bush (where fitted).

EVERY 500 HOURS OF TWELVE MONTHS WHICHEVER OCCURS FIRST

Renew intermediate and final fuel filter elements.

Clean element of dry type air cleaner or renew, (if not indicated earlier).

EVERY 2,500 HOURS

Arrange for examination and service of proprietary equipment, i.e. compressor, exhauster, starter motor, dynamo, etc.

Service atomisers.

Check and adjust tappets. See page E.8.

Post-Delivery Checkover

After a customer has taken delivery of his Perkins Diesel engine, it is advisable, in his own interest, that a general checkover of the engine be carried out after the first 25 hours in service.

It is also recommended that the following procedure be adopted where an engine has been laid up for a considerable period before it is again put into service.

The checkover should comprise the following points :—

1. Drain lubricating oil sump and re-fill up to the full mark on the dipstick with new clean oil (Do not overfill)
2. Renew the lubricating oil filter element or canister.
3. Check external nuts for tightness.
4. Check and adjust tappet clearances, 0.012 in (0,30 mm) cold. See page E.8.
5. Re-torque the cylinder head nuts in the correct sequences (see Figs. E14 or E.15). The correct procedure for re-tightening of cylinder nuts/setscrews is given on Page E.9.
6. Check fuel pipes from tank to fuel injection pump for leaks.
7. Check for lubricating oil leaks, and rectify if necessary.
8. Check hose clips for tightness.
9. Check cooling system for leaks and inspect radiator water level.
10. Check fan belt for tension.
11. Carry out test to check general performance of engine.
12. Check engine mounting bolts for tightness.

It is assumed that electrical equipment will have already been checked for such points as rate of charge, effectiveness of connections and circuits, etc.

Thereafter maintenance periods should be in accordance with the instructions given on the previous page.

PROTECTION OF AN ENGINE NOT IN SERVICE

The recommendations given below are to ensure that damage is prevented when an engine is removed from service for an extended period. Use these procedures immediately the engine is removed from service. The instructions for the use of POWERPART products are given on the outside of each container.

1. Thoroughly clean the outside of the engine.
2. Where a preservative fuel is to be used, drain the fuel system and fill with the preservative fuel. **POWERPART Lay-Up 1** can be added to the normal fuel to change it to a preservative fuel. If preservative fuel is not used, the system can be kept charged with normal fuel, but this will have to be drained and discarded at the end of the storage period together with the fuel filter element.
3. Run the engine until it is warm. Correct any fuel, lubricating oil or air leakage. Stop the engine and drain the lubricating oil sump.
4. Renew the lubricating oil filter canister or element.
5. Fill the sump to the full mark on the dipstick with clean new lubricating oil or with a correct preservative fluid. **POWERPART Lay-Up 2** can be added to the lubricating oil to give protection against corrosion during the period in storage. If a preservative fluid is used, this must be drained and normal lubricating oil used when the engine is returned to service.
6. Drain the cooling system, see Page C.5. To give protection against corrosion, it is better to fill the cooling system with a coolant that has a corrosion inhibitor. If frost protection is needed, use an antifreeze mixture. If no frost protection is needed, use water with an approved corrosion inhibitor mixture.
7. Run the engine for a short period to send the lubricating oil and coolant around the engine.
8. Clean out the engine breather pipe and seal the end of the pipe.
9. Remove the atomisers and spray **POWERPART Lay-Up 2** into each cylinder bore. If this is not available, clean engine lubricating oil will give a degree of protection. Spray into the cylinder bores 140 ml ($\frac{1}{4}$ pint) of lubricating oil divided evenly between the three cylinders.
10. Slowly turn the crankshaft one revolution and then install the atomisers complete with new seat washers.
11. Remove the air filter and any pipe installed between the air filter and induction manifold. Spray **POWERPART Lay-Up 2** into the induction manifold. Seal the manifold with waterproof tape.
12. Remove the exhaust pipe. Spray **POWERPART Lay-Up 2** into the exhaust manifold. Seal the manifold with waterproof tape.

13. Remove the lubricating oil filler cap. Spray **POWERPART Lay-Up 2** around the rocker shaft assembly. Fit the filler cap. Where the oil filler cap is not on the cylinder head cover, it will be necessary to remove the cover to spray the rocker shaft assembly.
14. Disconnect the battery and put it into safe storage in a fully charged condition. Before the battery is put into storage, give the battery terminals protection against corrosion. **POWERPART Lay-Up 3** can be used on the terminals.
15. Seal the vent pipe of the fuel tank or the fuel filler cap with waterproof tape.
16. Remove the fan belt and put into storage.
17. To prevent corrosion, spray the engine with **POWERPART Lay-Up 3.** Do not spray inside the alternator cooling fan area.

NOTE :

Before the engine is started after a period in storage, operate the starter motor with the engine stop control in the "off" position until oil pressure shows on the gauge or the oil warning light goes out. If a solenoid stop control is used, this will have to be disconnected for this operation.

If the engine protection is done correctly according to the above recommendations, no corrosion damage will normally occur. Perkins Engines Ltd., are not responsible for any damage that occurs in relation to a service storage period.

ENGINE COOLANT

The quality of the coolant used can have a large effect on the efficiency and life of the cooling system. The recommendations given below can be of assistance in the maintenance of a good cooling system with frost and/or corrosion protection.

1. Where possible, use clean soft water.
2. If an antifreeze mixture is used to prevent frost damage, it must have an ethylene glycol (ethanediol) base. An antifreeze that is to one of the standards given below or to an equal standard is acceptable if the pH value is kept within the range of 7.0-8.5 when diluted.

   U.K. BS 3151:1959
   'Ethanediol Antifreeze Type B with Sodium Benzoate and Sodium Nitrate Inhibitors'.

   U.S.A. ASTM 3306-74
   'Ethylene Glycol Base Engine Coolant'.

   Australia AS 2108-1977
   'Antifreeze Compounds and Corrosion Inhibitors for Engine Cooling Systems'.

   When Perkins POWERPART Antifreeze is used, the correct mixtures of antifreeze and water are as given below. Perkins POWERPART Antifreeze fully passes the above standards.

Lowest Temp. of Protection Needed	% Volume of POWERPART Antifreeze	Mixture-Ratio by Vol. POWERPART Antifreeze:Water
–12°C (10°F)	25	1:3
–18°C (0°F)	33	1:2
–25°C (–13°F)	40	1:1.5
–37°C (–34°F)	50	1:1
–60°C (–76°F)	66	2:1

   The quality of the antifreeze coolant must be checked at least once a year, for example, at the start of the cold period.
3. When frost protection is not necessary, it is still an advantage to use an approved antifreeze mixture as this gives protection against corrosion and also raises the boiling point of the coolant. A minimum concentration of 25% by volume of antifreeze is necessary, but it is our recommendation that a 33% concentration by volume is used.

   If an antifreeze is not used, add a correct corrosion inhibitor mixture to the water.

   Change the water/corrosion inhibitor mixture every six months or check according to the inhibitor manufacturer's recommendations.

   Note : Some corrosion inhibitor mixtures contain soluble oil which can have an adverse effect on some types of water hose.

If the correct procedures are not used, Perkins Engines Ltd. can not be held responsible for any frost or corrosion damage.

To Drain the Cooling System

1. Ensure that the machine is on level ground.
2. Remove the radiator filler cap.
3. Remove the drain plug from the side of the cylinder block (see engine views) to drain the engine. Ensure that the drain hole does not have any restriction.
4. Open the tap or remove the drain plug at the bottom of the radiator to drain the radiator. If a tap or plug is not fitted to the radiator, disconnect the bottom radiator hose.
5. Where necessary, flush the system with clean water.
6. Fit the drain plugs and radiator cap. Where necessary, close the radiator tap or connect the radiator hose.

SECTION D
Fault Finding

fault finding chart

Fault	Possible Cause
Low cranking speed	1, 2, 3, 4.
Will not start	5, 6, 7, 8, 9, 10, 12, 13, 14, 15, 16, 17, 18, 19, 20, 22, 31, 32, 33.
Difficult starting	5, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 18, 19, 20, 21, 22, 24, 29, 31, 32, 33.
Lack of power	8, 9, 10, 11, 12, 13, 14, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 31, 32, 33.
Misfiring	8, 9, 10, 12, 13, 14, 16, 18, 19, 20, 25, 26, 28, 29, 30, 32.
Excessive fuel consumption	11, 13, 14, 16, 18, 19, 20, 22, 23, 24, 25, 27, 28, 29, 31, 32, 33.
Black exhaust	11, 13, 14, 16, 18, 19, 20, 22, 24, 25, 27, 28, 29, 31, 32, 33.
Blue/white exhaust	4, 16, 18, 19, 20, 25, 27, 31, 33, 34, 35, 45, 56.
Low oil pressure	4, 36, 37, 38, 39, 40, 42, 43, 44, 58.
Knocking	9, 14, 16, 18, 19, 22, 26, 28, 29, 31, 33, 35, 36, 45, 46, 59.
Erratic running	7, 8, 9, 10, 11, 12, 13, 14, 16, 20, 21, 23, 26, 28, 29, 30, 33. 35, 45, 59.
Vibration	13, 14, 20, 23, 25, 26, 29, 30, 33, 45, 48, 49.
High oil pressure	4, 38, 41.
Overheating	11, 13, 14, 16, 18, 19, 24, 25, 45, 47, 50, 51, 52, 53, 54, 57.
Excessive crankcase pressure	25, 31, 33, 34, 45, 55.
Poor compression	11, 19, 25, 28, 29, 31, 32, 33, 34, 46, 59.
Starts and stops	10, 11, 12.

KEY TO FAULT FINDING CHART

1. Battery capacity low.
2. Bad electrical connections.
3. Faulty starter motor.
4. Incorrect grade of lubricating oil.
5. Low cranking speed.
6. Fuel tank empty.
7. Faulty stop control operation.
8. Blocked fuel feed pipe.
9. Faulty fuel lift pump.
10. Choked fuel filter.
11. Restriction in air cleaner or induction system.
12. Air in fuel system.
13. Faulty fuel injection pump.
14. Faulty atomisers or incorrect type.
15. Incorrect use of cold start equipment.
16. Faulty cold starting equipment.
17. Broken fuel injection pump drive.
18. Incorrect fuel pump timing.
19. Incorrect valve timing.
20. Poor compression.
21. Blocked fuel tank vent.
22. Incorrect type or grade of fuel.
23. Sticking throttle or restricted movement.
24. Exhaust pipe restriction.
25. Cylinder head gasket leaking.
26. Overheating.
27. Cold running.
28. Incorrect tappet adjustment.
29. Sticking valves.
30. Incorrect high pressure pipes.
31. Worn cylinder bores.
32. Pitted valves and seats.
33. Broken, worn or sticking piston ring/s.
34. Worn valve stems and guides.
35. Overfull air cleaner or use of incorrect grade of oil.
36. Worn or damaged bearings.
37. Insufficient oil in sump.
38. Inaccurate gauge.
39. Oil pump worn.
40. Pressure relief valve sticking open.
41. Pressure relief valve sticking closed.
42. Broken relief valve spring.
43. Faulty suction pipe.
44. Choked oil filter.
45. Piston seizure/pick up.
46. Incorrect piston height.
47. Damaged fan.
48. Faulty engine mounting (Housing).
49. Incorrectly aligned flywheel housing, or flywheel.
50. Faulty thermostat.
51. Restriction in water jacket.
52. Loose fan belt.
53. Choked radiator.
54. Faulty water pump.
55. Choked breather pipe.
56. Damaged valve stem oil deflectors (if fitted).
57. Coolant level too low.
58. Blocked sump strainer.
59. Broken valve spring.

SECTION E
Cylinder Head

The number of hours run has no bearing on when to overhaul the cylinder head because carbon, beyond a superficial coating does not form and accumulate in the combustion chambers and on the pistons as is the case with a petrol engine.

Ease of starting and performance are the determining factors. Therefore the cylinder head should only be removed when it is absolutely necessary.

All 3.152 engines have 45° valve seats.

With D3.152 engines prior to Engine No. CE - - - - - U584638F the majority of valve seats were 45°. However, 35° seats were used on these earlier D3.152 engines rated above 2,250 rev/min, uprated AD3.152 engines and a few engines rated up to 2,250 rev/min. A fuel injection pump setting code (see pump data plate) beginning with TW50 or WW47E normally indicates 35° seats on these earlier D3.152 engines.

As from Engine No. CE - - - - - U584638F, all D3.152 engines have 35° seats.

To Remove the Cylinder Head

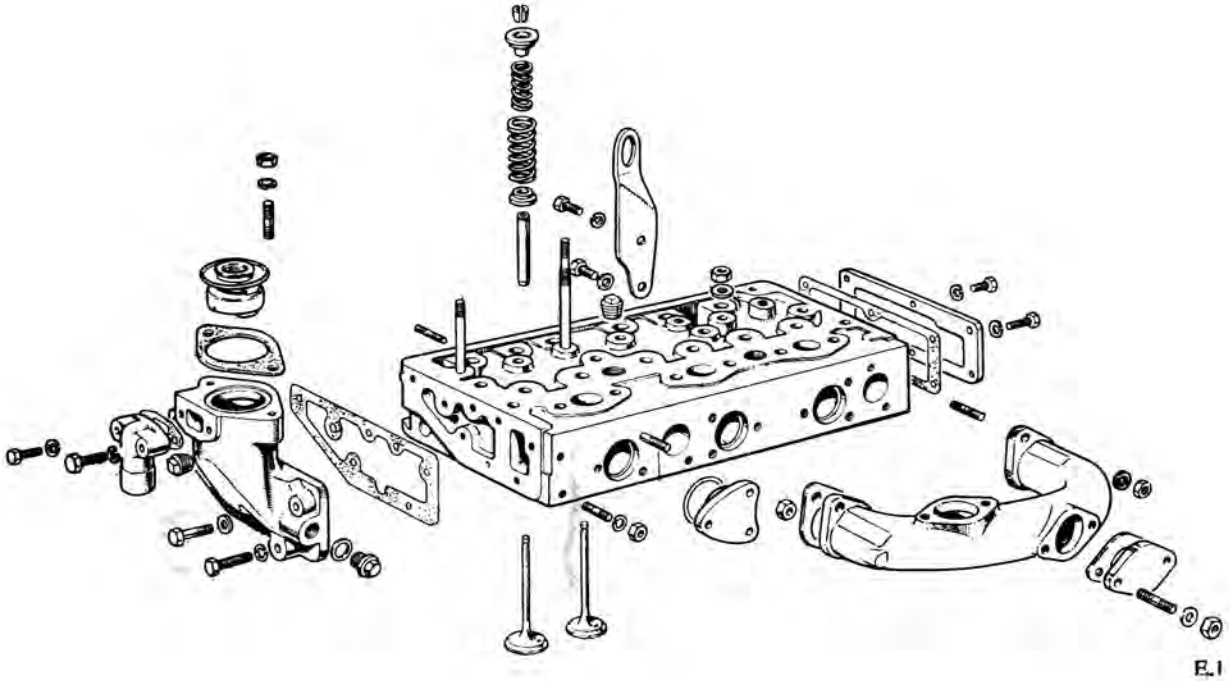
1. Drain water from radiator and cylinder block.
2. Detach water connections from thermostat housing on front of cylinder head.
3. Remove water connections to and from exhaust manifold (flame-proof engines only).
4. Remove air cleaner.
5. Detach cold starting equipment connections.
6. Remove the oil pipe from the camshaft oil reducer to the cylinder head
7. Disconnect the exhaust pipe from the engine exhaust manifold.
8. Remove the injection pipes from the fuel pump to atomisers.

Warning : Cover the fuel pump delivery ports with suitable protective caps.

9. Remove atomiser leak-off pipes.
10. Remove the atomisers. (See Fig. E.2 or E.3). On D3.152 engines, the inside atomiser securing nut is lengthened for ease of access on agricultural applications, see Fig. E.3.
11. Remove the cylinder head cover.
12. Disconnect the oil pipe to rocker shaft.
13. Remove the rocker shaft assembly, bringing above-named oil pipe with it.
14. Remove the cylinder head nuts/setscrews.
15. Remove the cylinder head. Do not insert a screwdriver or any other sharp instrument between the cylinder head and block. Place the cylinder head on a flat surface, preferably wood, to avoid damage.

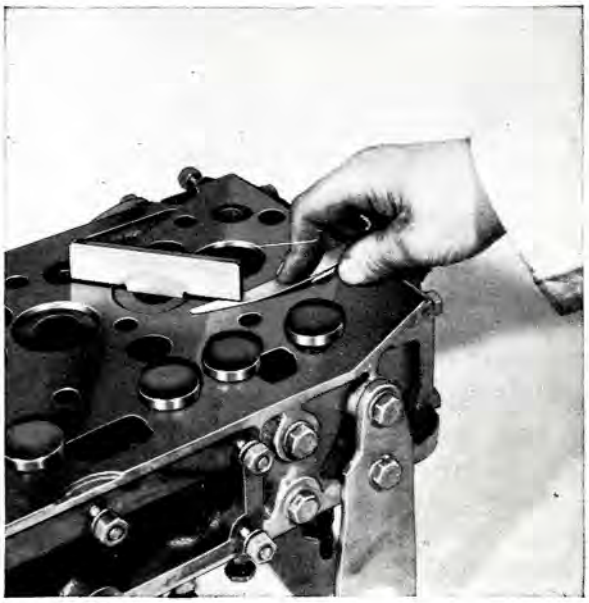
To Remove the Valves

Depress the spring cap, and springs by means of a valve spring compressor and remove the two



E.1

E.2



E.4

half conical collets. Remove the spring caps, springs and washers thus liberating the valves which can be taken out. The valves and valve seats should be reconditioned in the orthodox way, using grinding compound or by means of specialised equipment.

The valve face and seat angle is 45° with the exception of certain earlier D3.152 engines and all current D3.152 engines (see Page E.1) where the inlet and exhaust valve seat angle is 35°.

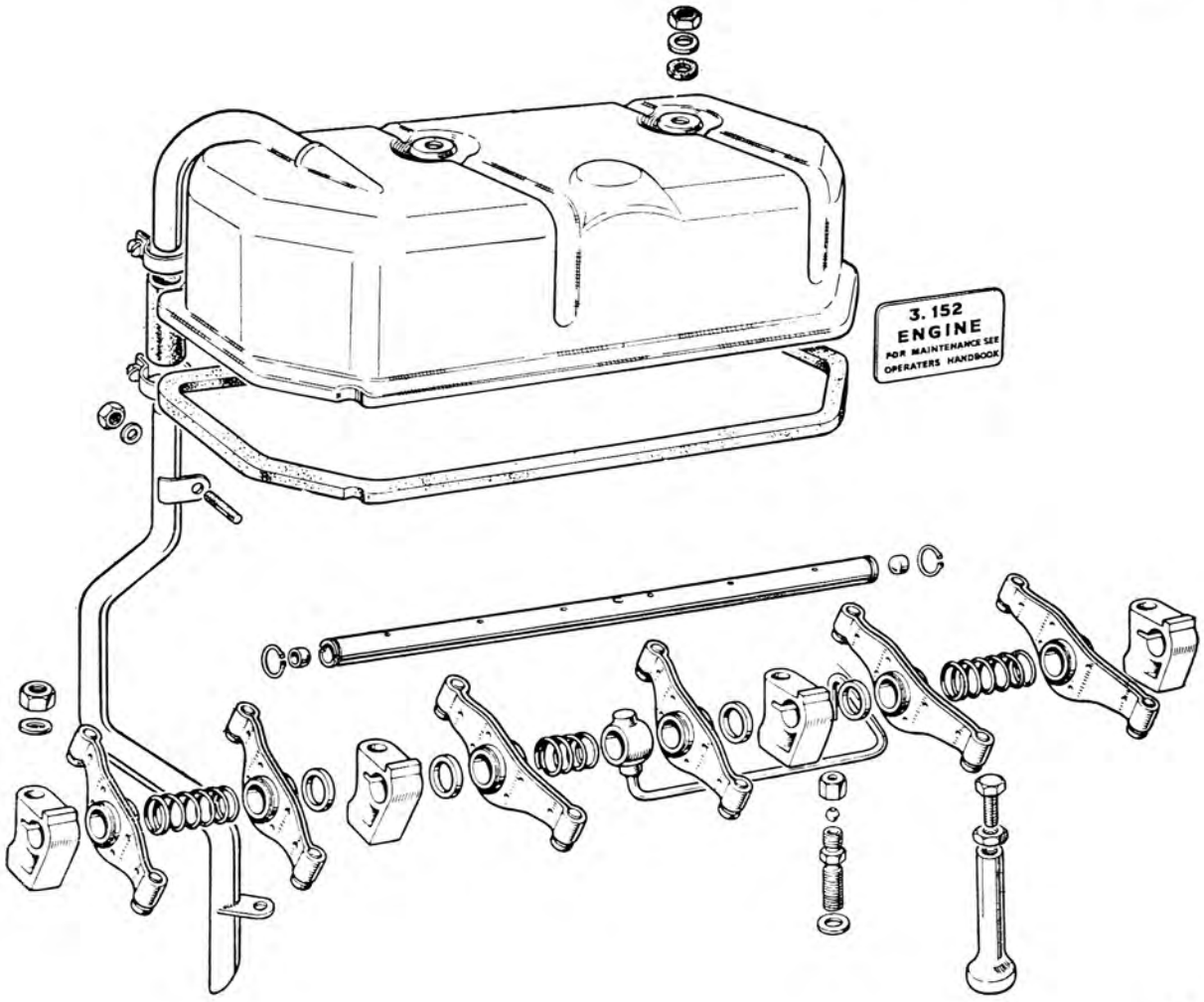
E.3

Do not forget that the efficiency of a diesel engine depends largely on the maintenance of good compression. Contact between valve and seatings must therefore be the best possible.

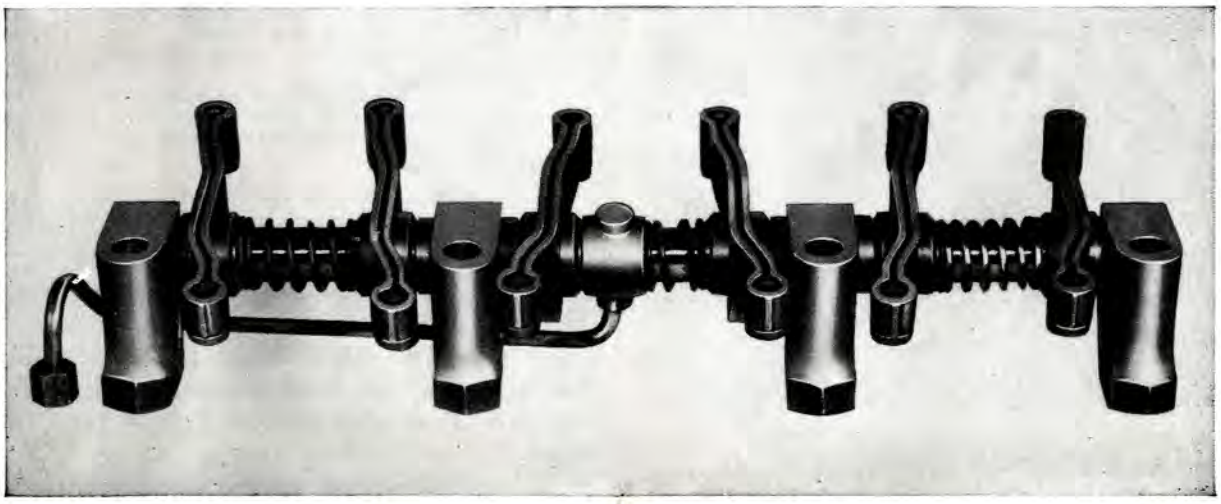
Care should be taken to avoid unnecessary grinding away of the seat as the maximum clearance between the valve head and the cylinder head bottom face should not exceed 0.140 in (3,5 mm) for the 3.152 engine and 0.084 in (2,13 mm) for D3.152 engines with 45° valve seats. On D3.152 engines with 35° valve seats, the inlet valve head depth should not exceed 0.072 in (1,83 mm) and the exhaust valve head depth should not exceed 0.083 in (2,11 mm). This can easily be checked by means of a suitable gauge and feelers (Fig. E.4).

Where engines have to conform to the smoke density regulation B.S.AU 141a : 1971, then the maximum valve depth for 3.152 engines must not exceed 0.085 in (2,15 mm) and for D3.152 engines, the valve depth production limits as given in Section B must not be exceeded.

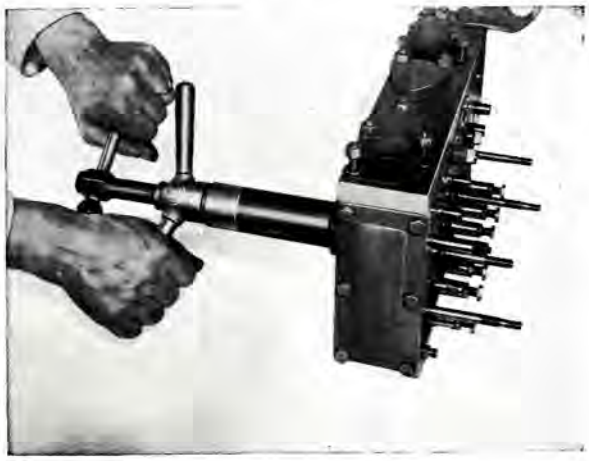
The valve seats for the 3.152 engine and the 35° seats, where used on D3.152 engines, are recessed into the cylinder head and a groove is cut where the proper valve seat ends in the mitred recess in the head. When valves have been reconditioned several times, it is possible that the valve may become masked by sinking too low in the cylinder head and in these circumstances the groove referred to should be re-cut accordingly.



E.5



E.6



E.7

The 45° valve seat for the D3.152 engine has a 30° "flare" machined between the seat and the cylinder head face.

With earlier engines, the valves were numbered and the cylinder head was marked with corresponding numbers.

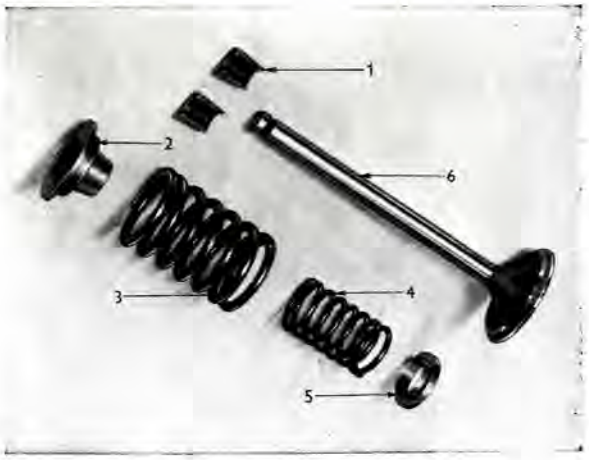
With current engines, the valves and seats are not numbered and where a valve is to be used again, it should be suitably marked to ensure it is replaced in its original position.

Rocker Levers and Bushes

Wash the rocker shaft assembly thoroughly in paraffin.

Examine the rocker bushes for wear. The rockers should be an easy fit on the shaft without excessive side play.

If the rocker bushes are worn, it will be necessary to replace with a new rocker. The rockers are supplied as a complete assembly and new bushes cannot be fitted.



E.8
Exploded View of Valve Assembly.

1. Collet.
2. Spring Cap.
3. Outer Valve Spring.
4. Inner Valve Spring.
5. Washer.
6. Valve.

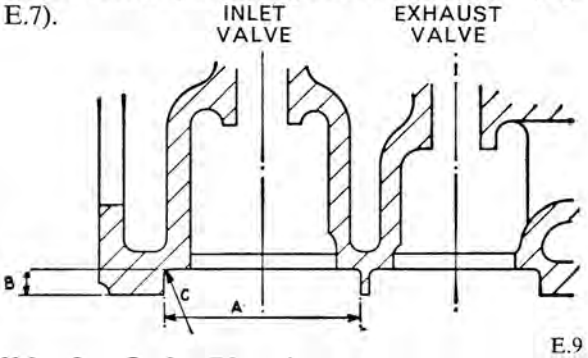
When dismantling rocker shaft assemblies make careful note of the order of assembly of the various parts, supports, distance pieces, springs and rockers, so that re-assembly may be facilitated and that left and right-hand rockers are correctly placed and come opposite their respective tappets and valves. (See Fig. E.6).

Valve Guides

Examine the valve guides for wear, if necessary replace with new guides.

Clean the new guides, removing any burrs.

When pressing in a valve guide, care must be taken to ensure it is fitted the right way round. Both ends are chamfered, one at 45°, the other at 20°. The end that is chamfered at 20° is also recessed in the bore. This end should be inserted into the cylinder head top face and pulled into the parent bore until the opposite end (chamfered at 45°) protrudes 0.580/0.594 in (14,73 to 15,09 mm) above the top face. Tool 21825026 with puller bar 21825027 can be used for removing and fitting valve guides and valve guide stop 21825029 will ensure correct positioning of the valve guide (Fig. E.7).



E.9

Valve Seat Cutting Dimensions

Inlet (3.152)
A.—1.874 to 1.875 in (47,60 to 47,62 mm).
B.—0.248 to 0.250 in (6,30 to 6,35 mm).
C.—0.040 to 0.050 in (1,02 to 1,30 mm) Radius.

Exhaust (3.152)
A.—1.624 to 1.625 in (41,25 to 41,28 mm).
B.—0.248 to 0.250 in (6,30 to 6,35 mm).
C.—0.040 to 0.050 in (1,02 to 1,30 mm) Radius.

Exhaust (D3.152)
A.—1.678 to 1.679 in (42,62 to 42,64 mm).
B.—0.310 to 0.312 in (7,87 to 7,92 mm).
C.—0.015 in (0,38 mm) Maximum Radius.

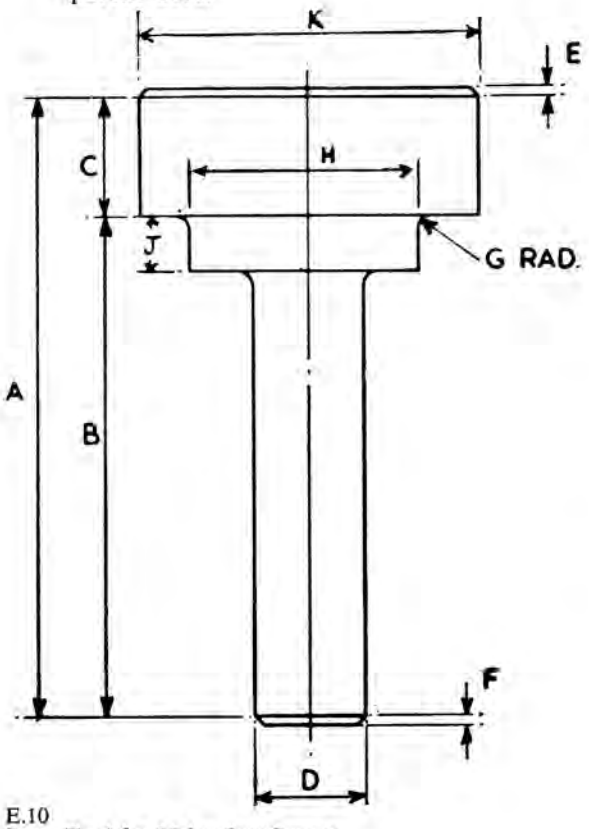
Valve Seat Inserts

It is permissible to fit valve seat inserts to both 3.152 engine valve seats and the 45° exhaust valve seat of the D3.152 engine where the original seating has become unserviceable due to damage or to the maximum valve recession tolerance having been exceeded. This should prove successful providing that the listed tolerances are strictly adhered to and that Genuine Perkins Parts are used.

This operation must never be attempted with a worn valve guide in position. All machining must be completed from the bore of a new valve guide

Operation

1. Press out the old valve guide and clean the parent bore.

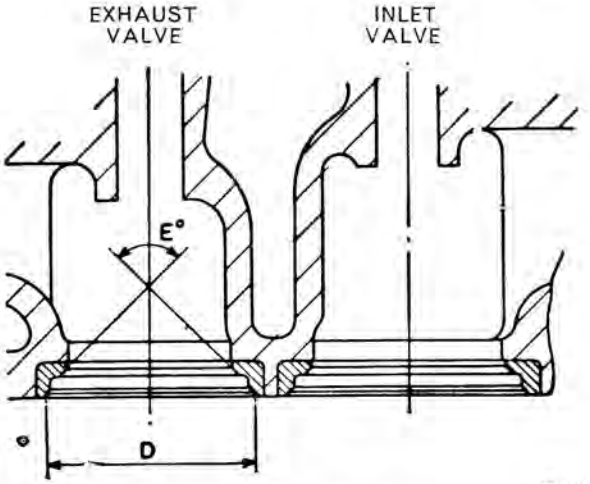


E.10
Press Tool for Valve Seat Inserts.

Inlet Dimensions (3.152)
A.—2¾ in (69,85 mm).
B.—2 in (50,80 mm).
C.—¾ in (19,05 mm).
D.—0.309 to 0.310 in (7,85 to 7,87 mm).
E.—1/16 in (0,06 mm) at 45°.
F.—1/16 in (0,06 mm) at 45°.
G.—1/32 in (0,03 mm) Radius.
H.—1.401 to 1.402 in (35,58 to 35,61 mm)
J.—0.212 to 0.215 in (5,38 to 5,46 mm).
K.—1.855 to 1.865 in (47,12 to 47,37 mm).

Exhaust Dimensions (3.152)
A.—2¾ in (69,85 mm).
B.—2 in (50,80 mm).
C.—¾ in. (19,05 mm).
D.—0.309 to 0.310 in (7,85 to 7,87 mm).
E.—1/16 in (0,06 mm) at 45°.
F.—1/16 in (0,06 mm) at 45°.
G.—1/32 in (0,03 mm) Radius.
H.—1.182 to 1.183 in (30,02 to 30,05 mm)
J.—0.212 to 0.215 in (5,38 to 5,46 mm).
K.—1.605 to 1.615 in (40,77 to 41,02 mm).

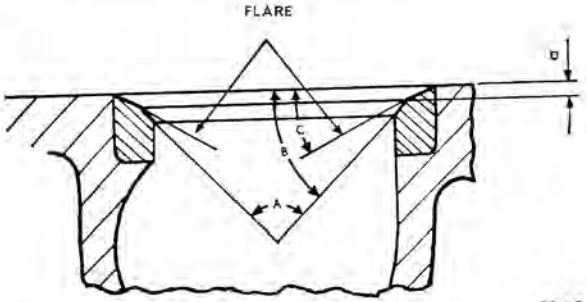
Exhaust Dimensions (D3.152)
A.—3½ in (88,90 mm).
B.—2¾ in (69,85 mm).
C.—¾ in (19,05 mm).
D.—0.309 to 0.310 in (7,85 to 7,87 mm).
E.—1/16 in (0,06 mm) at 45°.
F.—1/16 in (0,06 mm) at 45°.
G.—1/32 in (0,03 mm) Radius.
H.—1.200 to 1.201 in (30,48 to 30,50 mm).
J.—¼ in (6,35 mm)
K.—1.667 to 1.677 in (42,34 to 42,59 mm).
Material EN32A Case Hardened and Ground.



E.11
Valve Insert Finished Dimensions (3.152).

Inlet
D.—1.704 to 1.714 in (43,28 to 43,53 mm).
E.—90°.

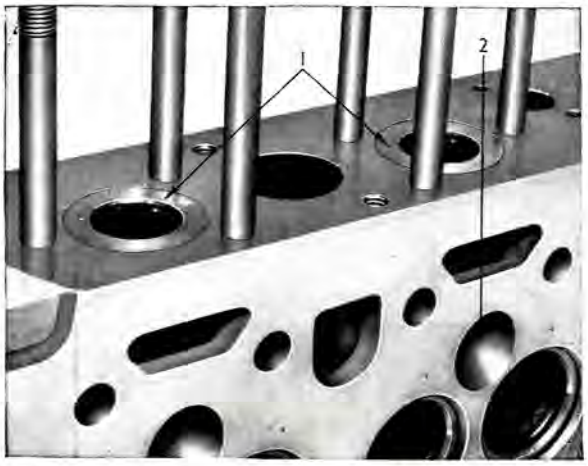
Exhaust
D.—1.485 to 1.495 in (37,72 to 37,97 mm)
E.—90°.



E.12
Valve Insert Finished Dimensions (D3.152).

Exhaust
A.—90°. C.—30°.
B.—45°. D.—0.130 to 0.138 in (3,30 to 3,51 mm).

2. Press in new valve guide to act as a pilot for subsequent operations.
3. Using a suitable cutting tool, the old seats should be cut away to the dimensions shown in Fig. E.9. Care should be taken that the cutting is clean, and that all the swarf is removed.
4. Using a dolly machined to the dimensions given in Fig. E.10, again using the valve guide bore as a pilot, press home the insert using steady pressure from a hand or hydraulic press. Under no circumstances should the insert be hammered in or lubricated.
5. Visually inspect to ensure that the insert is pressed in squarely and is flush with the bottom of the recess. See Fig. E.11.
6. For D3.152 45° exhaust valve inserts only, using valve guide bore as a pilot, machine the



E.13
3.152 Flameproof Engines only.
1. Combustion Chamber Inserts.
2. Combustion Chamber Throat.

'flare" to the dimensions given in Fig. E.12.

7. Re-cut the valve seat so that the valve head recession is within limits specified on page B.9.

Tappets

The tappets slide in holes bored in the cylinder head. The wear, under normal conditions, is negligible.

The running clearance between the top of the tappet and the rocker should be 0.012 in (0,30 mm) when the engine is cold.

When adjusting this clearance, tighten tappet locknut effectively, so that it does not slacken in service.

Combustion Chamber Caps and Joints (3.152)

It is not as a rule necessary to remove the covers of the combustion chambers during top overhaul as carbon rarely forms in these chambers.

If, for any reason, these covers are removed, new copper joints should be fitted when they are replaced.

If new copper joints are not available, the old ones may be used provided that they are softened before being fitted.

To soften these copper joints, heat them to a dull red heat and quench in cold water.

Again having in mind the importance of good compression for efficient operation of a diesel engine, special care is necessary when refitting these covers to ensure that there are no leakages at the joints.

NOTE : With flame-proof applications, combustion chamber covers are not fitted. Instead, detachable steel inserts are fitted to form the outer half of the combustion chambers (See Fig. E.13) and the chambers are sealed by the exhaust manifold.

General

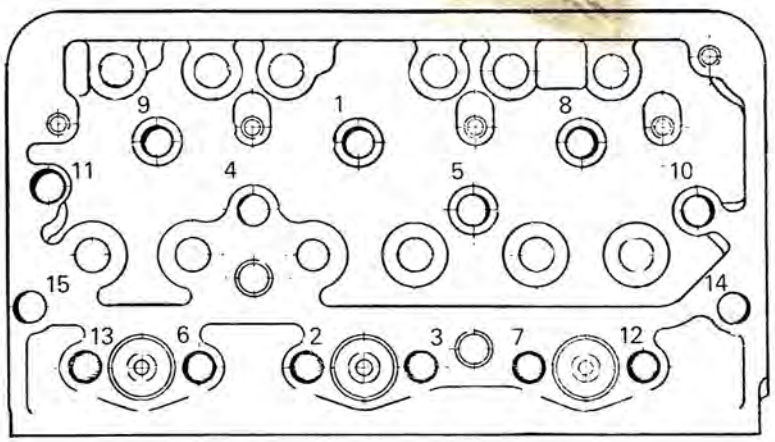
All studs on the cylinder head and top face of the cylinder block should be examined for looseness, damaged threads, etc. The cylinder head nuts/setscrews should also be examined to ensure the threads are not damaged.

All joint faces should be examined for pitting and defacement.

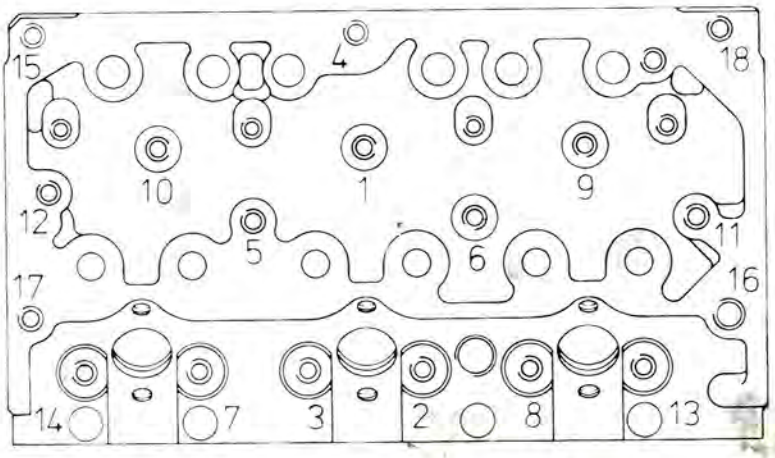
Wash out and thoroughly clean the water passages in the head, subsequently drying out and finally cleaning with compressed air.

If the water jacket of the cylinder head shows signs of excessive scale a proprietary brand of descaling solution should be used.

If possible, the cylinder head should be water tested for leaks with warm water at a water pressure of 30 lbf/in² (2.11 kgf/cm²) or 207 kN/m².



E.14
Cylinder Head Tightening Sequence (3.152 engines).



E.15

Cylinder Head Tightening Sequence (D3.152 Engines).

IMPORTANT

Should the cylinder head bottom face of the 3.152 engine become damaged, it is permissible to re-skim providing the overall thickness is not reduced below 2.980 in (75,69 mm). In the case of the D3.152 engine, a maximum of 0.012 in (0,30 mm) may be removed from the head face, providing the nozzle protrusion does not exceed 0.184 in (4,67 mm) or 0.179 in (4,55 mm) for up-rated AD3.152 engines. **Shim washers must on no account be used under the atomisers to reduce nozzle protrusion.**

The relative valve head depth, however, must afterwards be checked and if necessary corrected to conform with the limits quoted on Page B.9.

Cylinder Head Retaining

Different methods of cylinder head retaining have been used on 3.152 and D3.152 engines.

Originally, the cylinder head was secured to the block by studs and nuts.

E.16

As from the following engine numbers the cylinder head nuts were changed to nuts and set-screws :—

152U21416CL
152U98250D
152UA28411DSL
152UA431805DL

On D3.152 engines, all but two of the original studs were changed to setscrews. The two retained studs were fitted to the holes marked 13 and 14 in Fig. E.15. Three different lengths of setscrew were used and it is important that they be fitted in their correct positions, i.e. the four shorter $3\frac{1}{4}$ in (82,5 mm) should be used in positions 7,3,2 and 8. The three mid length setscrews $3\frac{5}{8}$ in (92mm) should be used in positions 15, 4 and 18. The nine longer setscrews of $3\frac{7}{8}$ (98,4 mm) should be at positions 10, 1, 9, 12, 5, 6, 11, 17 and 16.

On 3.152 engines, the studs are replaced by set-screws except for the six which are used to secure the atomisers. These studs are retained in positions 13, 6, 2, 3, 7 and 12 in Fig. E.14.

A further change of cylinder head retaining was made to D3.152 engines as from engine number CE - - - - - U597494F whereby the three setscrews in positions 15, 4 and 18 in Fig. E.15 were changed to studs.

NOTE : Where the cylinder head is secured by all nuts, the tightening torque is 60 lbf ft (8,3 kgf m) or 81 Nm. Where both nuts and setscrews are used, the tightening torque is 70 lbf ft (9,68 kgf m) or 95 Nm. On later engines the nuts and setscrews have an integral headwasher.

Re-assembly and Replacing

Replace valves, washers, springs, collars and collets, taking care that the numbers on the valves

E.17

correspond to the numbers stamped adjacent to the valve seats.

On the majority of engines only one spring is fitted to each valve but, for a few applications, two springs are fitted. Different valve spring seating washers are fitted according to the number of springs employed.

Replace combustion chamber caps and joints if these have been removed.

Before replacing the cylinder head it is extremely important to ensure that the faces of the cylinder block and cylinder head are perfectly clean.

A new cylinder head gasket should be used. The gasket is marked to indicate how it should be fitted. Where an Elring gasket part number 3681E006 is used, this must be fitted dry.

NOTE : For flame-proof applications, a special cylinder head gasket is required.

Cover both sides of the gasket with a thin coating of good jointing compound and place over the cylinder head studs.

When the underface of the cylinder head is perfectly clean, the head may be lowered into position on its studs and the nuts/setscrews tightened down in the order shown in Fig. E.14 or E.15. The cylinder head nuts/setscrews should be pulled down to the recommended torque (See Page B.1).

NOTE : There is a different torque depending on whether the cylinder head fixings are all nuts or nuts and setscrews.

Replace atomisers (See Page N.5).

Replace the rocker shaft assembly, but before tightening the securing nuts the rocker shaft should be set so as to ensure correct lubrication of the assembly. For earlier engines, the correct position for the shaft is when the slot in the end of the shaft is set 40° after the vertical position, i.e. with the slot pointing towards the sharp corner at the top of the bracket (see Fig. E.16). On later engines the slot has been removed and correct location of the shaft is ensured by a dowel through one of the rocker shaft securing brackets (see 1, Fig. E.18).

When the rocker shaft is correctly positioned, tighten the securing nuts and set the tappet clearances to 0.012 in (0,30 mm).

Connect up pipes and make connections as listed under "To remove the Cylinder Head."

Provision is made in the cylinder head water outlet for the housing of a thermostat which must be fitted. On no account must the engine be started without a thermostat fitted, otherwise overheating of the engine may occur.

ADJUSTING TAPPET CLEARANCE

The three throw 120° crankshaft makes it necessarry to adopt a slightly different sequence for tappet adjustment to the normally accepted procedure for four and six cylinder engines.

Tappet clearances for both inlet and exhaust should be set to 0.012 in (0,30 mm) cold.

To adjust clearances on engines with a flywheel T.D.C. mark proceed as follows :—

Remove the rubber plug in the inspection hole on the flywheel housing.

Rotate the crankshaft until the T.D.C. line on the flywheel is in the centre of the inspection hole and No. 1 piston is on compression stroke (both valves fully closed).

Check and adjust clearances as necessary on Nos. 1, 2, 3 and 5 valves. (Fig. E.17).

Turn crankshaft one revolution (360°) and repeat for Nos. 4 and 6 valves (T.D.C. mark visible through inspection hole).

Replace rubber plug in flywheel housing.

To adjust clearances (Fig. E.17) without a T.D.C. mark, proceed as follows :—

Turn the crankshaft until the valves of No. 1 cylinder are rocking (inlet valve opening and exhaust valve closing).

In this position, check and adjust clearances, as necessary, on Nos. 4 and 6 valves (No. 1 valve at front of engine).

Temporarily mark the crankshaft pulley and

the adjacent point on the timing case cover and turn the crankshaft one complete revolution (360°) until the marks re-align.

In this position, adjust the clearances on Nos. 1, 2, 3 and 5 valves.

Starting the Engine

Proceed as instructed on Page C.1.

After warming up to operating temperature, the engine should be stopped and the rocker shaft and atomisers removed when the head securing nuts/setscrews can again be re-torqued, these being tightened in the order shown in Fig. E.14 or E.15.

NOTE : When retightening cylinder head nuts/setscrews, the engine coolant outlet temperature should not be less than 170°F (77°C).

If the nut/setscrew moves when retightening, then tighten up to the torque quoted on Page B.1.

If the nut/setscrew does not move before the correct torque is achieved, then slacken off 1/12 to 1/6 (30° to 60°) of a turn and retighten to the correct figure.

After retightening all the nuts/setscrews, the first 10 positions should be rechecked without further slackening off to ascertain they are still tightened to the torque quoted.

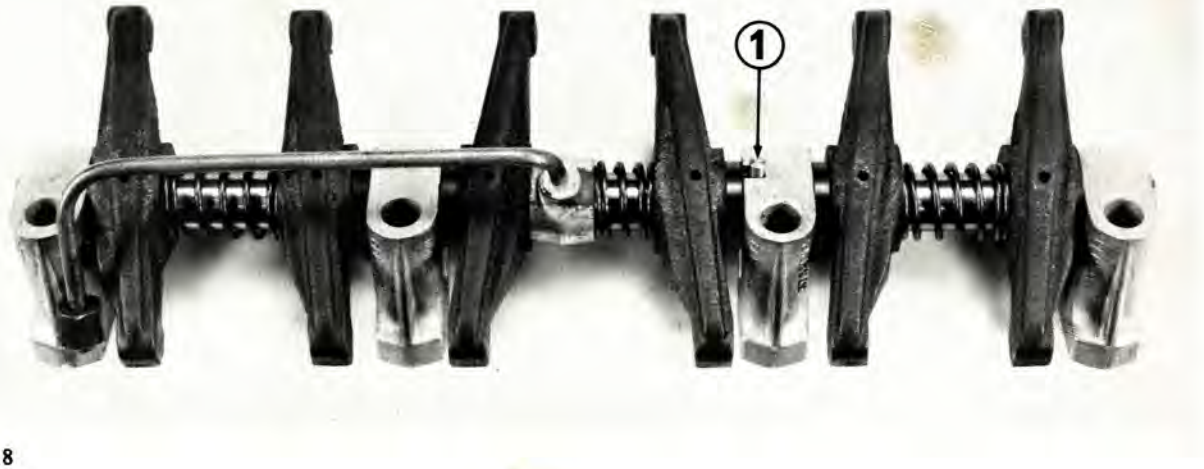
Refit the rocker shaft and re-set tappet clearance to 0.012 in (0,30 mm).

Refit the cylinder head cover and replace air cleaner.

A new joint should be fitted under the cylinder head cover and care should be taken to see that it is correctly placed, otherwise oil may leak away in a considerable quantity, enough to starve the engine of oil if left unchecked.

The cylinder head securing nuts should be re-torqued again after 25 hours running (not necessary where an Elring cylinder head gasket part number 3681E006 is fitted).

See above for correct retightening procedure.



E.18

SECTION F
Pistons and Connecting Rods

The pistons are of special light aluminium alloy flat topped for the 3.152/A3.152 engine, with a toroidal cavity in the crown (Fig. F.2) for the D3.152/AD3.152 engine and a flat bottomed cavity in the crown for up-rated AD3.152 engines. They are secured to the connecting rods by means of fully floating gudgeon pins which work in thin wall steel backed lead bronze lined bushes fitted in the small ends of the connecting rods. Circlips are provided in the pistons to secure the gudgeon pins in position.

Five piston rings are fitted to each piston on all 3.152 engines and most D3.152 engines rated up to 2,250 rev/min. Four rings are fitted to each piston on D3.152 engines rated above 2,250 rev/min, up-rated AD3.152 engines and a few D3.152 engines rated up to 2,250 rev/min. A fuel injection pump setting code (see pump data plate) beginning with TW50 or WW47E normally indicates four ring pistons on D3.152 engines.

The piston rings are all fitted above the gudgeon pin except for the bottom scraper ring on five ring pistons.

The connecting rod big ends are split at right angles to the axis of the rods, the caps being secured by two bolts and nuts.

Always ensure that big end nuts are replaced by new, once they are removed.

The big end bearings are of the thin wall type consisting of a thin steel shell lined with plated copper lead or alternatively aluminium tin.

To ensure correct replacement, the pistons are marked 1 to 3, number 1 being at the front of the engine. The number can be found stamped on each piston crown.

The connecting rods and caps, are also marked. On one side they are stamped with a number corresponding to their position in the engine.

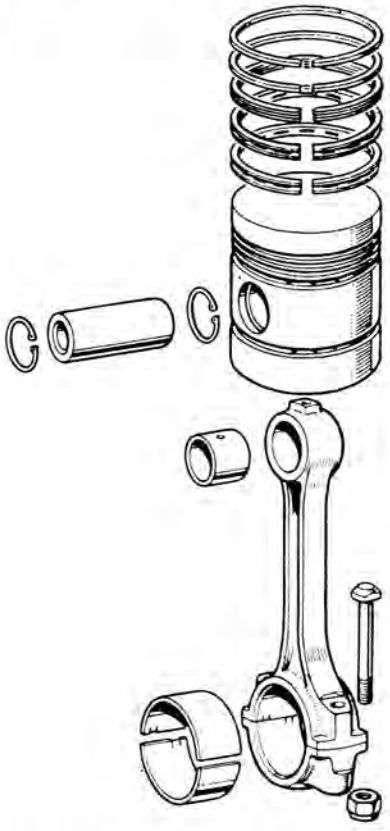
To Remove Pistons and Connecting Rods.

1. Remove cylinder head assembly (See Page E.1).
2. Remove sump (See Page L.6).
3. Remove oil pump (See Page L.6).
4. Turn the engine until one connecting rod is at bottom centre. Remove bolts and nuts securing the connecting rod cap.
5. Remove the connecting rod cap and both top and bottom half bearing shells (See Fig. F.3).
6. The piston and connecting rod can then be pushed out of the top of the cylinder block (See Fig. F.4).
7. Continue operations until all three pistons and connecting rods have been removed.
8. Keep all pistons, connecting rods, caps, bearing shells, bolts and nuts together as separate assemblies, each to each as marked.

To Remove Gudgeon Pins

Remove the circlips from the pistons, using a pair of long nosed pliers.

The gudgeon pins can now be removed and the connecting rods separated from the pistons. If the pins are tight in the pistons, warm the latter in liquid to a temperature 100° to 120°F (38—49°C) which will free the pins.



F.1

To Fit New Small End Bushes

The small end bushes are a press fit in the connecting rods.

Press out the old bushes using a suitable press.

Remove any sharp edges around the connecting rod small end parent bores.

F.2

Press in the new bushes using a suitable dolly, at the same time ensuring that the oil holes in the bushes coincide with the holes in the top of the connecting rods.

Ream out the new bushes in situ to suit their respective gudgeon pins (See Page B.7), and check for parallelism and twist.

To Assemble Piston and Connecting Rod.

If the original pistons are to be used again they should be re-assembled to their respective connecting rods, i.e., the piston stamped No. 1 should be fitted to the connecting rod stamped No. 1. It is also advisable that the pistons be suitably marked on their crowns before removal so they can be re-assembled in the relevant position in their respective cylinder bores.

Pistons for the D3.152 engine should be fitted with the offset cavity in the crown towards the side of the connecting rod that is marked with the identification number.

Offer the connecting rod to the piston and insert the gudgeon pin. To do this it is advisable to warm the pistons in liquid to a temperature of 100° to 120°F. (38° to 49°C.) The gudgeon pin can then easily be pushed into position.

Fit the circlips to the piston. It is difficult to advise as to when new circlips should be fitted. but in the event of an engine being in service for a lengthy period, it is advisable that new circlips be used, during reassembly.

Fitting New Rings

The piston and rings should be thoroughly washed to remove any oil and grease.

Check piston rings for correct gap (See Page B.5). When checking the gap of the coil spring loaded scraper ring, the spring should be fitted in the ring to expand it against the cylinder liner.

In worn cylinder bores, the gaps should be checked at the unworn top of the bore, after any carbon has been removed.

Fit the rings to the piston in the following positions (reading from the top of the piston).

Chrome Plated Liners (3.152 Engines)

1. Plain compression ring.
2. Taper face compression ring.
3. Laminated compression ring.
4. Slotted scraper ring (maxigroove).
5. Slotted scraper ring (maxigroove).

The taper faced compression rings are marked "T" or "TOP" to facilitate their correct fitting.

F.3

Cast Iron Liners (3.152/A3.152 and D3.152/AD3.152 Engines rated up to 2,250 rev/min)

In the following order (reading from the top of the piston).

1. Chrome plated compression.
2. Plain compression.
3. Laminated compression.
*4. Spring loaded, laminated scraper.
5. Slotted scraper.

*For 3.152 engines rated above 2,250 rev/min a slotted scraper ring is used.

Note: A few applications using D3.152 engines rated up to 2,250 rev/min employ the ring layout given below for higher rated D3.152 engines. A fuel injection pump setting code (see pump data plate) beginning with TW50 or WW47E normally indicates this ring arrangement.

D3.152 Engines rated above 2,250 rev/min

1. Chrome plated compression
2. Plain compression.
3. Internally stepped compression.
4. Chrome faced, coil spring loaded, scraper ring.

Up-rated AD3.152 Engines

1. Chrome plated compression.
2. Internally stepped compression
3. Internally stepped compression.
4. Chrome faced, coil spring loaded, scraper ring.

To fit the coil spring loaded scraper ring, fit the coil spring in the piston groove, ensuring that the latch pin enters both ends of the spring and then

F.4

F.5

fit the ring over the spring with the spring locating in the recess in the ring and the ring gap diametrically opposite to the latch pin.

When fitting internally stepped rings, the stepped edge should be fitted towards the top of the piston.

When fitting new rings to original pistons, clean out the piston ring grooves using the old ring from the appropriate groove for the purpose.

The pistons should be carefully examined for bruising of the ring grooves and to ensure that the rings move truly in their grooves. In addition the piston skirt should be examined and if there is any scoring the piston must not be used again.

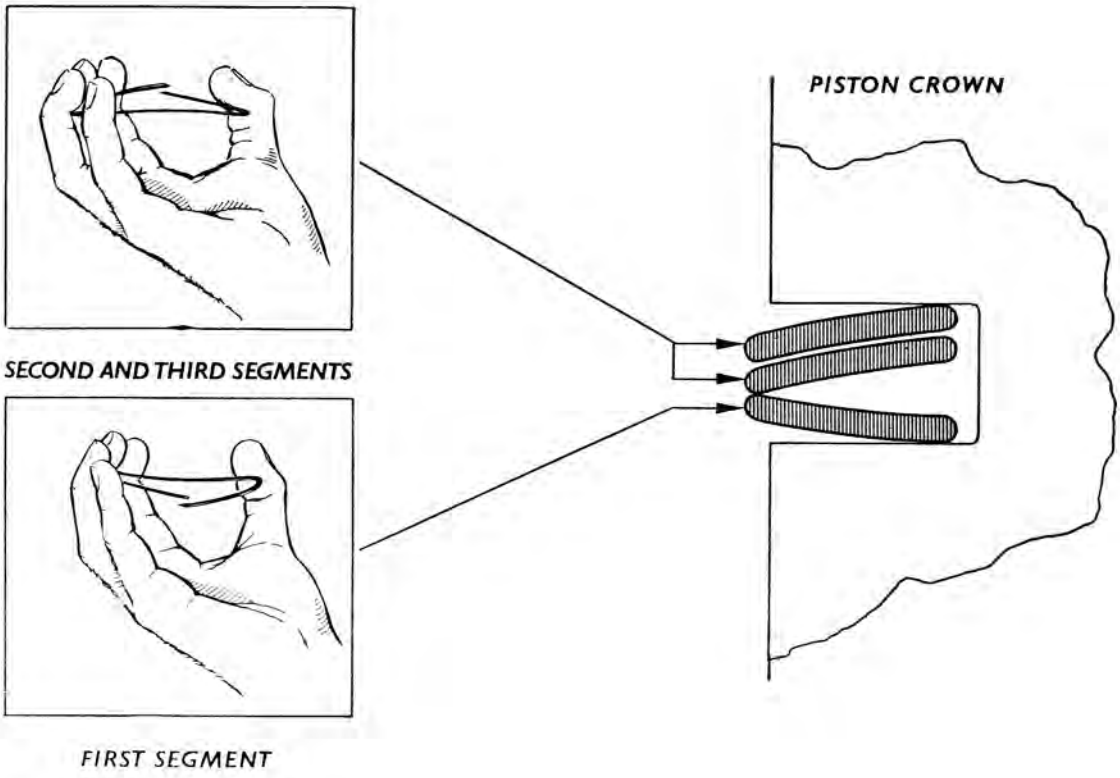
Laminated Compression Rings

The laminated compression ring fitted in the third ring groove varies inasmuch as on earlier engines it comprised three segments, whereas on later engines it comprises four segments in one groove.

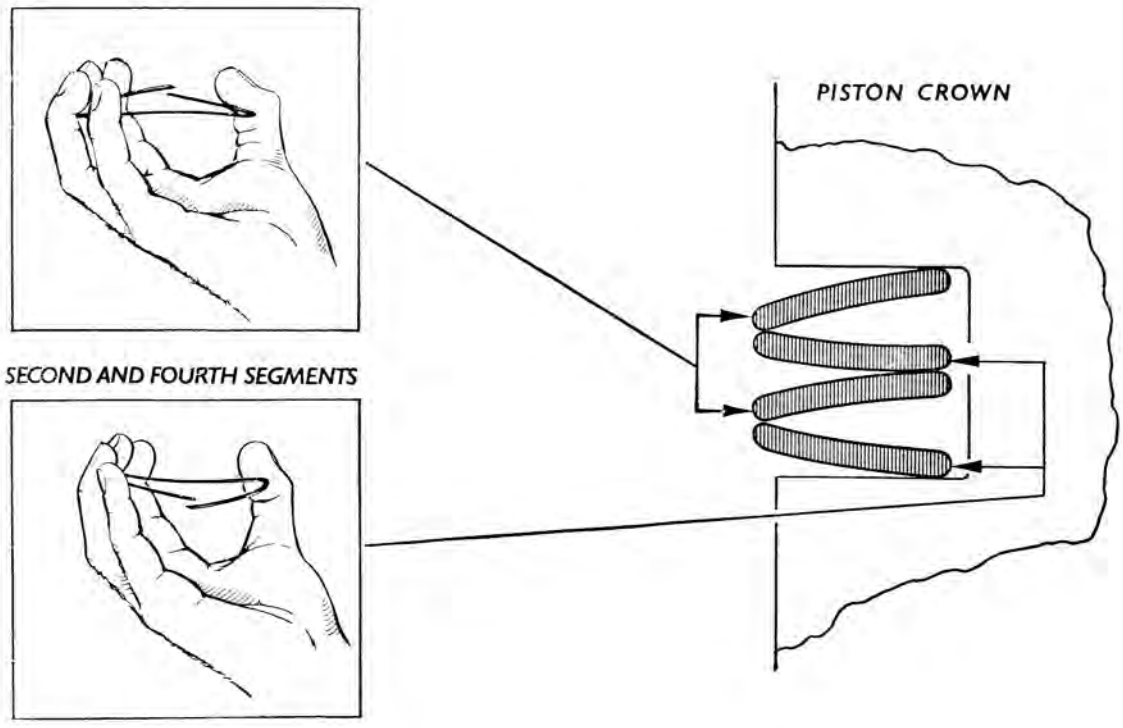
Three Segment Type (see Fig. F.6).

When fitting this type of laminated compression ring, care should be taken to see that the laminations are correctly assembled to the piston.

1. Fit the first segment to the piston so that when held horizontally in the palm of the hand and radially compressed, the ring ends point downwards. Position this ring at the bottom of the groove with the gap over the gudgeon pin bore.


PISTON CROWN
SECOND AND THIRD SEGMENTS
FIRST SEGMENT

F.6


PISTON CROWN
SECOND AND FOURTH SEGMENTS
FIRST AND THIRD SEGMENTS

F.7

2. Fit the second segment on the top of the first so that when held compressed as described above, the ring ends point upwards. Position the gap at 180° to the first segment gap.
3. The third segment should be fitted on the top of the second so that when held and compressed as described, the ring ends point upwards. Position the gap immediately above that of the first segment.

Four Segment Type (see Fig. F.7).

To fit this type of laminated compression ring, proceed as follows :—

1. Fit the first segment to the piston so that when held horizontally in the palm of the hand and radially compressed, the ring ends point downwards. Position this ring at the bottom of the groove with the gap over the gudgeon pin bore.
2. Fit the second segment on the top of the first so that when held compressed as described above, the ring ends point upwards. Position the gap at 180° to the first segment gap.
3. The third segment should be fitted on the top of the second so that when compressed as described, the ring ends point downwards. Position the gap immediately above that of the first segment.
4. Fit the fourth segment on the top of the third so that when held and compressed, the ring ends point upwards. Position the gap above that of the second segment.

To Fit Spring Loaded Scraper Ring (Fig. F.8)

This spring loaded scraper ring comprises one internal expander ring (1), two rail rings (2) each side of the spiral ring (3).

1. Fit internal expander ring.
2. Fit lower two rail rings.
3. Fit spiral ring.
4. Fit upper two rail rings.

The rail ring gaps should be equally spaced around the piston.

To Fit Spring Loaded Scraper Ring (Fig. F.9)

This spring loaded scraper ring is an alternative to that shown in Fig. F.8 and consists of 4 flat segments, one cupped segment and a spacer.

1. Fit two flat segments.
2. Fit the spacer.
3. Fit the third flat segment immediately above the spacer.
4. Fit the cupped segment with cup down above the flat segment.
5. Fit remaining flat segment above the cupped segment.

The segment gaps should be equally spaced around the piston.

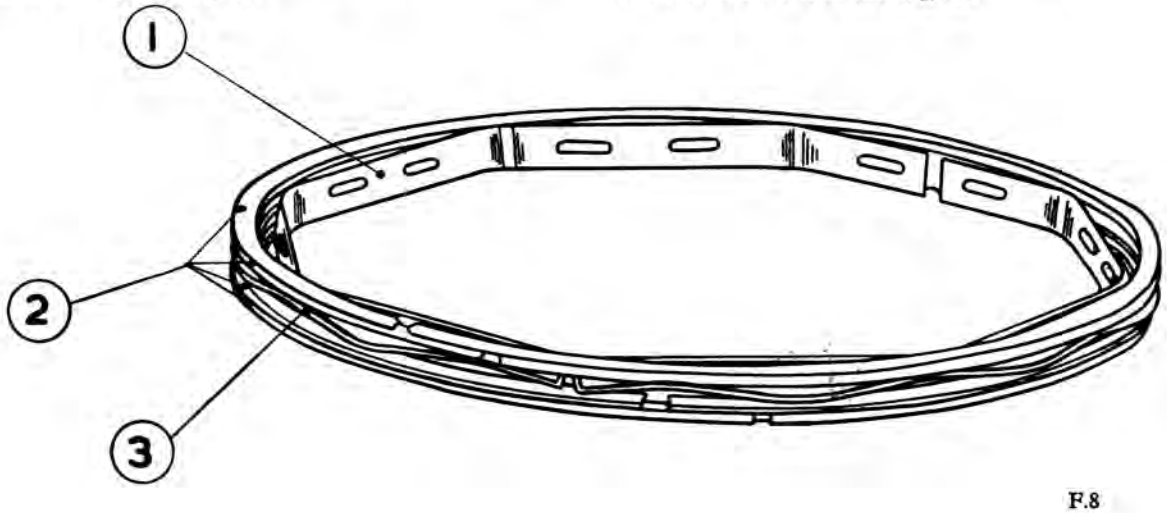
To Replace Pistons and Connecting Rods

Connecting rods and caps, are plainly marked to indicate their original position in the engine. The numbers are stamped on that side of the connecting rod and cap which is machined to take the locating lips of the big end bearings.

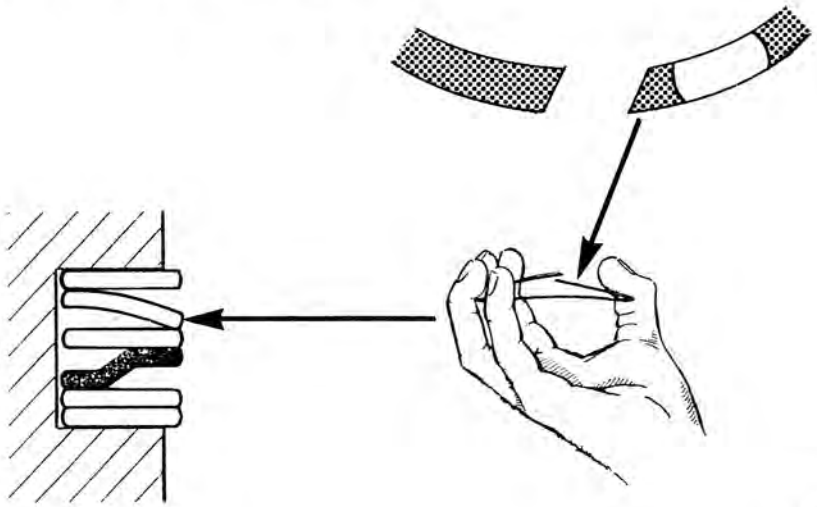
Before fitting pistons, the cylinder bores should be given a liberal coating of clean lubricating oil.

When fitting pistons and connecting rods to the cylinder block and crankshaft, ensure that the side of the connecting rod which is stamped with the number goes to the fuel pump side of the engine.

For D3.152 engines, also ensure that the word "Front" or arrow marked on the piston crown is towards the front of the engine.



F.8



F.9

Insert the pistons and connecting rods into the cylinder bores from the top (See Fig. F.10), ensuring the piston and rod stamped No. 1 are fitted into No. 1 bore and No. 2 into No. 2 bore and so on commencing from the front of the engine.

To minimise the possibility of breaking piston rings it is advisable to use a piston guide. Take care not to damage the rings. Should the piston accidentally drop partly into the cylinder bore and is held suspended by a piston ring, it must be taken out again and the ring examined to see if it is cracked or broken.

Turn the crankshaft until the appropriate crankpin is at bottom centre, pull the connecting rod to the crankpin and insert the half bearing.

Fit the cap and cap half bearing, ensuring that the markings on connecting rod and cap coincide.

The nuts used on the big end bolts should not be used a second time but should be replaced by new whenever they are removed.

Tighten the connecting rod nuts using a torque wrench set to the tension given on page B.1.

Three types of connecting rod nuts have been used. The original nuts were self locking, these being replaced by Cadmimum plated nuts which are of a bright finish. The latest Phosphated nuts have a dull black finish.

Rotate crankshaft by hand and note that all parts move freely.

Check the piston height in relation to the top face of the cylinder as described below.

F.10

Fitting New Pistons

An important point to note is that when the crankpin is at top dead centre the crown of the piston must be 0.000/0.005 in (0,00/0,13 mm) below the top face of the cylinder block for the 3.152 engine, between 0.004 in (0,102 mm) above and 0.001 in (0,025 mm) below the top face of the cylinder block for the D3.152 engine and between 0.001/0.006 in (0,03/0,15 mm) below the cylinder block top face for the up-rated AD3.152 engine.

With most new pistons, a machining allowance is provided on the crown of the piston and the necessary amount must be removed in a lathe to give the clearance quoted above. Some pistons may be available that do not require topping.

To determine the amount it may be necessary to remove from the piston crown, the piston assembly and connecting rod should be fitted to the cylinder block and crankshaft as previously described.

When assembled, turn the crankshaft to bring the piston to T.D.C. and check the distance between the piston crown and the top face of the cylinder block. Tool PD41B can be used to check piston height (Fig. F.11).

Carry out this operation with each new piston in turn. When the necessary amount has been removed from the piston crowns, assemble to the cylinder block. Tool 21825019 can be used to check piston height (Fig. F.11).

The distance between the cylinder block face and piston crown should now be checked to ensure the limit has been maintained when that piston is at T.D.C. (See Fig. F.11).

F.11

SECTION G
Cylinder Block and Liners

The cylinder block is fitted with renewable thin wall cast iron or chrome plated dry cylinder liners. Production cast iron cylinder liners are an interference fit and require boring and honing to size after fitting. Service cast iron liners and all chrome liners are a transitional fit and being prefinished, require no further machining after fitting.

Only cast iron liners are fitted to current A3.152 and AD3.152 engines.

Production and service cast iron liners are interchangeable, but cast iron and chrome liners are not interchangeable due to the difference in liner flange dimensions and the accommodating recess in the cylinder block.

Cylinder liners fitted to 3.152/A3.152 and D3.152/AD3.152 engines cannot be rebored. When they are worn to an extent whereby engine performance is affected, they should be renewed.

For some applications, a pre-finished bush is fitted in the block to provide a bearing for the front camshaft journal. When renewing this bush, ensure that the oil hole in the bush corresponds with the oil passage in the block and the end of the bush marked "FRONT" is fitted towards the front of the block.

To Remove Liners

1. Remove cylinder head as detailed in Section H.
2. Remove the piston and connecting rod assemblies, crankshaft and all component parts of the cylinder block as detailed in the appropriate sections of this manual.
3. Remove cylinder head studs from the cylinder block.
4. Press or draw the liners out through the top of the cylinder block (Fig. G.2), ensuring no damage is done to the parent bores (cast iron production liners are an interference fit and should be removed with a heavy duty press).

Preparation for Fitting New Liners

Great care must be taken in handling, transit and storage of new chrome plated liners, as the slightest burr or damage to this thin wall liner is sufficient to cause considerable distortion of the liner bore when fitted.

After removal of the old liners, the parent bore must be thoroughly cleaned both in the top recess of the liner flange and in the parent bore itself.

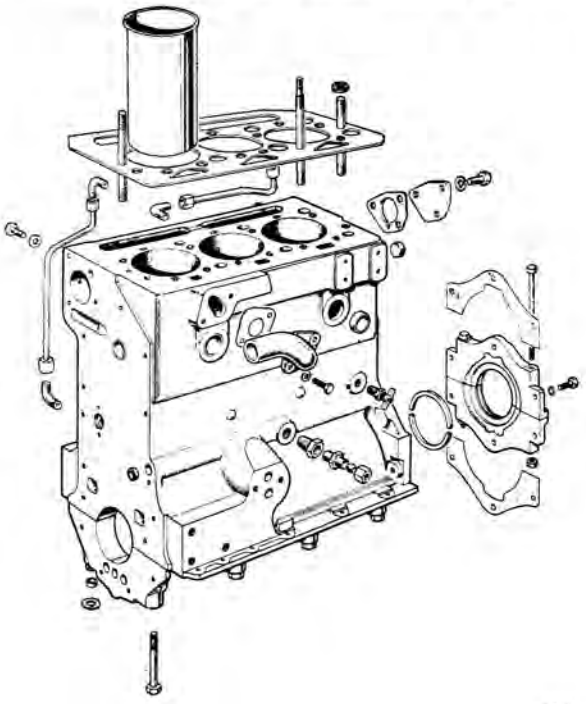
A check must be made to ensure that the whole areas of contact with the liners in the cylinder block are free from burrs, corrosion or damage. Remove any burrs present.

Ensure that the new liner is thoroughly clean before fitting. If cleaning fluid is used to wash the liner, it is important that the liner be thoroughly dried and well oiled before fitting.

Throughout the whole operation, extreme cleanliness is essential as the entry of the smallest particle of grit or other foreign matter is sufficient to cause local distortion of the liner bore.

To Fit New Liners

1. Lubricate the outside diameter of the liners with clean oil which should be applied by means of a pressure can. The use of a brush is not recommended.
2. Press or draw in the new liners (Fig. G.3) using a suitable shouldered metal disc ensuring that the flanges at the top of the liners do not foul the counter-bore at the top of the parent bore thus causing distortion at the top of the internal diameter of the liner.



When fully home, the top face of the liner flange should be between 0.001 in (0,02 mm) and 0.007 in (0,18 mm) below the top face of the cylinder block for chrome plated liners and between 0.004 in (0,10 mm) above to 0.004 in (0,10 mm) below the top face of the cylinder block for cast iron liners.

In order to effect this, it is permissible to use shims under the cylinder liner flange. These are 0.005 in (0,13 mm) thick. Part No. 33127107. Before fitting a cylinder liner, the depth of the flange and the appropriate recess in the cylinder block should be measured to ascertain whether a shim or shims (if any) are required to give the correct liner height in relation to the cylinder block top face.

The fit of the new liners in the parent bore is a transition fit, that is the limits extend from minus 0.001 in (0,02mm) to plus 0.001 in (0,02 mm).

3. It is advisable to allow a settling period to elapse before checking the fitted internal bore diameter of the liner. The acceptable limit is 3.6005/3.603 in (91,45/91,52 mm) for chrome plated liners.

For cast iron service liners, the acceptable limit is 3.6015/3.6025 in (91,48/91,50 mm). Each new liner should be checked in three positions — top, centre and bottom; the readings being taken transversely and parallel to the centre line of the cylinder block at each position.

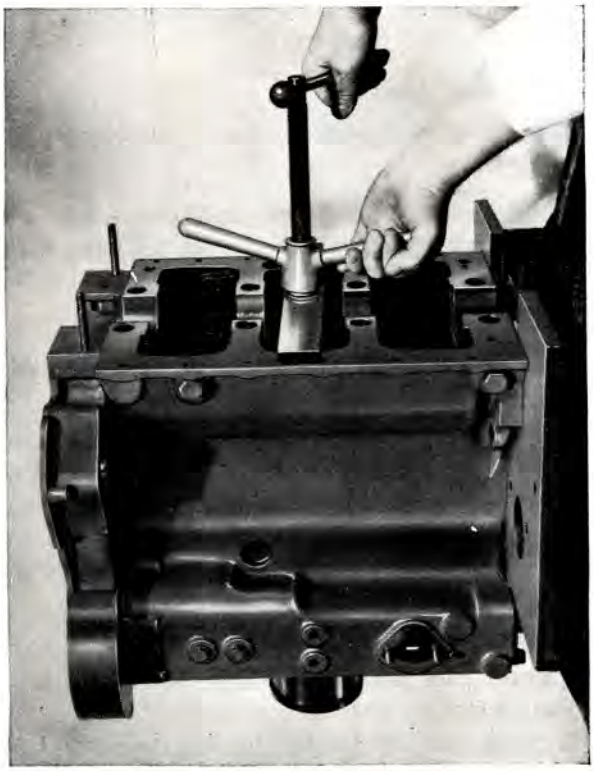
4. Having fitted the new liners, the remainder of the re-assembly operations are a reversal of the removal procedure.

Unbored Cast Iron Liners

If desired and where the necessary boring equipment is available, unbored cast iron liners (as used in factory production) may be used to replace existing cast iron liners. These are an interference fit in the cylinder block as compared with the transitional fit of pre-finished liners and require boring and honing in situ to a diameter of 3.6015/3.6025 in (91,48/91,50 mm).

For best results the bores should be diamond honed at an inclusive angle of 30° to 35° followed by plateau honing at an inclusive angle of 15° to 35° to a finish of 32/48 micro inches (0,8/1,2 microns) centre line average.

G.2



G.3

When fitting unbored liners to uprated AD3.152 engines, they should be :—

1. Diamond honed followed by plateau hone.
2. Diamond cross hatch to be 30° to 35° (horizontally included angle).
3. Uniformally cut in both directions throughout length of liner
4. Clean cut and free of torn and folded metal.
5. Micro average 50-60 centre line average in the range 45-65 centre line average after diamond honing.
   Micro average 35-45 centre line average in the range of 32-48 centre line average after plateau honing.
6. Plateau area to be $\frac{1}{3}$ to $\frac{1}{2}$ of surface measured by visual assessment of fax film and micro section.
7. Free of burnish or glaze.
8. Thoroughly clean and free from embedded particles.

Oversize Cylinder Liners

Oversize outside diameter cylinder liners may be fitted to factory rebuilt engines and are available for fitment in service where the standard parent bore is enlarged to remove damage.

They are available as follows :—

Oversize	Description
0.005 in (0,13 mm)	Chromed — pre-finished
0.010 in (0,25 mm)	Cast Iron Flanged — Bore and hone

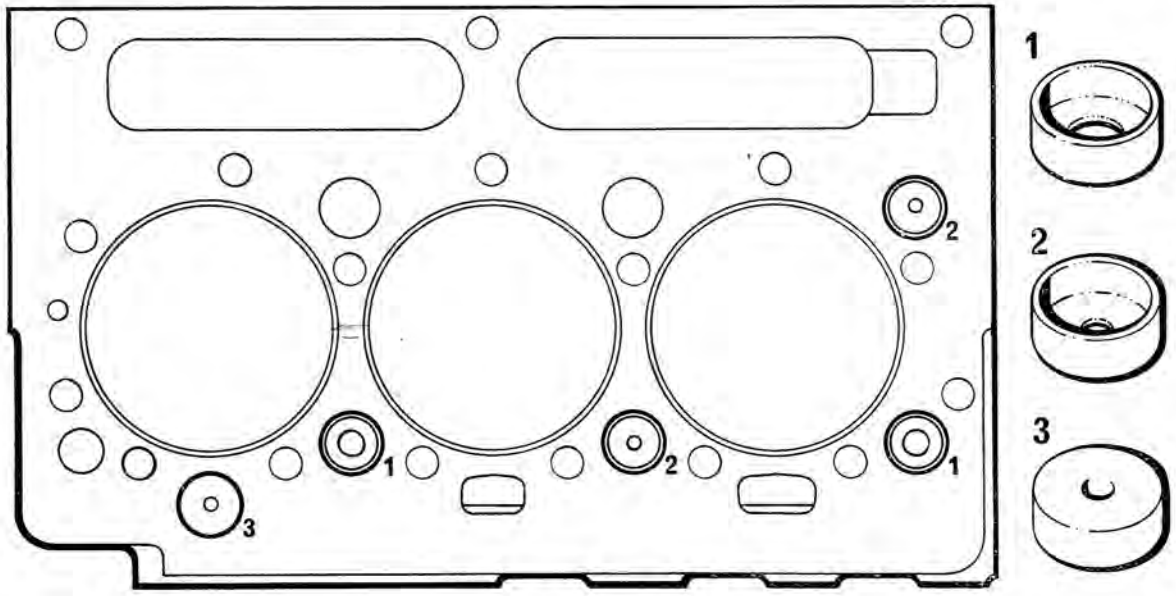
Where a parent bore is reclaimed in service, it should be machined to the dimension by adding the appropriate liner oversize to the standard parent bore diameter given in Page B.3. The top of the parent bore must be re-chamfered after machining.

Where 0.005 in and 0.010 in oversize liners are fitted, the liner oversize is stamped on the cylinder block top face between the liner and the edge of the cylinder block.

Coolant Restriction Plugs

On up-rated AD3.152 engines, some of the water passages at the top of the cylinder block are fitted with restriction plugs. If these are removed for any reason, ensure that the correct size of restriction plug is fitted into its relevant position as shown in Fig. G.4 and that the plugs do not protrude above the cylinder block face.

The plug (3) is fitted in the cylinder block before the top face is machined on production and if this plug is renewed, the thickness of the new plug will have to be reduced so that the top face of the plug when fitted, is flush with the top face of the block.



G.4

SECTION H
Crankshaft and Main Bearings

The crankshaft runs in four pre-finished replaceable shell bearings lined with plated copper lead or alternatively aluminium tin.

The crankshaft is fitted with two cast iron counter weights, one at the front crank web and one at the rear crank web to give full rotating balance.

The main bearings are located in position by tabs fitting into slots machined in the bearing housings.

The seal at the rear end of the crankshaft is either a rope type seal in a split housing or a lip seal fitted in a one-piece housing.

NOTE: The tab washers and shim washers originally fitted under the main bearing cap setscrew heads have been deleted on production and may be discontinued in service, providing the correct torque as given on Page B.1 is observed.

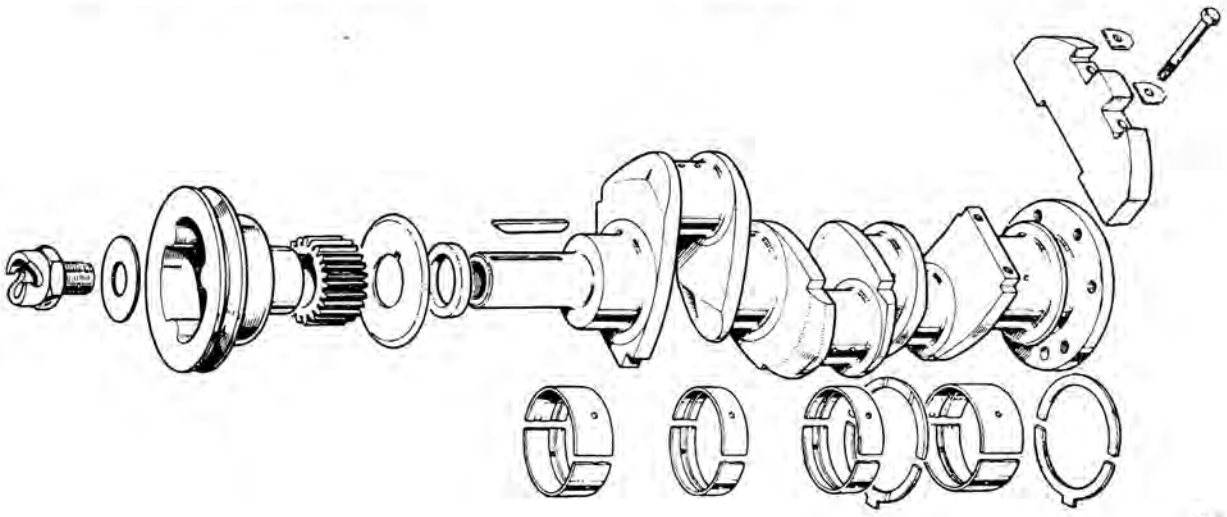
Fitting New Main Bearings and Thrust Washers

Under normal circumstances, by the time the main bearings and thrust washers require renewing, the crankshaft will need to be removed for regrinding. However, if for any reason one or more of the bearings or thrust washers have to be renewed or removed for inspection, this can be carried out without removing the crankshaft from the engine.

1. To remove a main bearing, take off the cap of the bearing in question. For the rear main bearing cap, see (1) overleaf.
2. Do not remove more than one bearing cap at a time.
3. Slacken the remaining bearing cap setscrews one or two turns.
4. Remove the lower half of the bearing from the bearing cap.
5. With a suitable piece of wood push out the top half of the bearing by rotating it on the crankshaft, applying the tool to the side opposite the bearing lip. (See Fig. H.2). The locating lips are on the camshaft side of the engine.
6. Inspect the bearing shells and if they require renewing, insert a new half bearing in the top, inserting the plain end first. Fit new half bearing to cap.
7. Replace cap and tighten setscrews lightly before proceeding to the next bearing.
8. Having replaced the bearing and caps, pull down the setscrews with a torque wrench set to the tension given on page B.1.

The thrust washers fit in recesses provided on either side of the rear main bearing housing and cap (Fig. H.3).

1. To renew the thrust washers, remove the rear main bearing cap. Before doing this it will be necessary to remove the two nuts securing the two halves of the rope type rear main oil seal or release the lip seal and housing.



H.2

2. Remove the two bottom half thrust washers from the main bearing cap.
3. The two top half thrust washers can be removed by sliding them round from one side with a piece of wood or similar material and rotating them until they can be removed.
4. To fit new thrust washers, lightly coat the two upper halves with lubricating oil and slide in the recesses provided on either side of the rear main bearing housing. The steel side of the thrust washers should be towards the bearing housing.
5. Renew the main bearing cap "O" rings (lip seal crankshafts only). Lightly coat the butt faces of the cap with Perkins (Hylomar) Jointing Compound. For lip seal crankshafts, only coat outboard of the grooves machined in the cap butt faces and ensure that the grooves are free of jointing compound.
6. Place the two lower halves on either side of the rear main bearing cap and replace the cap.
7. The bearing cap securing setscrews should be pulled down with a torque wrench set to the tension given on page B.1. Check crankshaft end float (Fig. H.4).
8. Finally secure the two halves of the rope type rear main oil seal housing by means of the two self locking nuts or refit the lip seal and housing.

To Remove Crankshaft

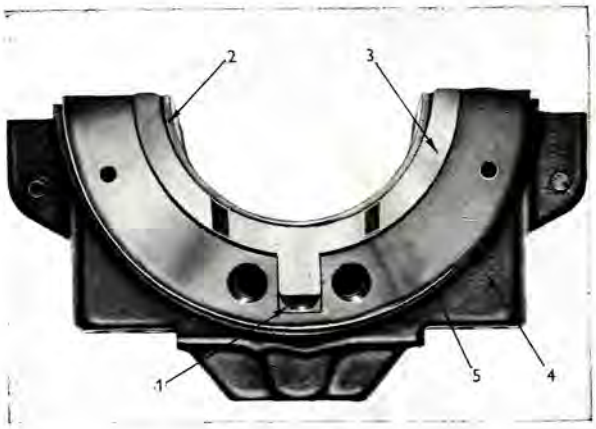
1. Remove sump and lubricating oil pump (See Page L.6).
2. Remove water pump (See Page M.1).
3. Remove crankshaft pulley.
4. Take off timing case front cover and remove idler gear.
5. Remove starter motor, flywheel & flywheel housing When removing the flywheel, fit two guide studs in the crankshaft flange for support.
6. Remove connecting rod caps and big-end bearings.
7. Remove the bolts securing the two halves or the crankshaft rear main oil seal housing or remove the lip seal and housing.
8. Where necessary release the tab washers locking the main bearing setscrews and remove the setscrews.
9. Remove main bearing caps and half bearings
10. Lift out crankshaft.

Should it be necessary to replace the crankshaft gear, it should be ascertained that the scribed timing mark is to the front when the gear is fitted. The distance piece between the gear and the crankshaft should be fitted with the chamfer to the inside.

If the main bearings are to be used again, they should be suitably marked so that they may be replaced in the same position from which they were removed.

Balance Weights

Should it at any time be necessary to replace crankshaft balance weights, these are normally supplied in wired pairs and must be fitted as a pair. Should a single balance weight require replacing, this must be done selectively so that there is no greater weight variation than 1 oz (0,28 Kg.) between individual weights.



H.3

Rear Main Bearing Cap.

1. Oil Drain Holes (from Rear Oil Seal).
2. Rear Main Bearing Shell.
3. Thrust Washer.
4. Bearing Cap.
5. Joint (Bearing Cap to Sump).

Regrinding the Crankshaft

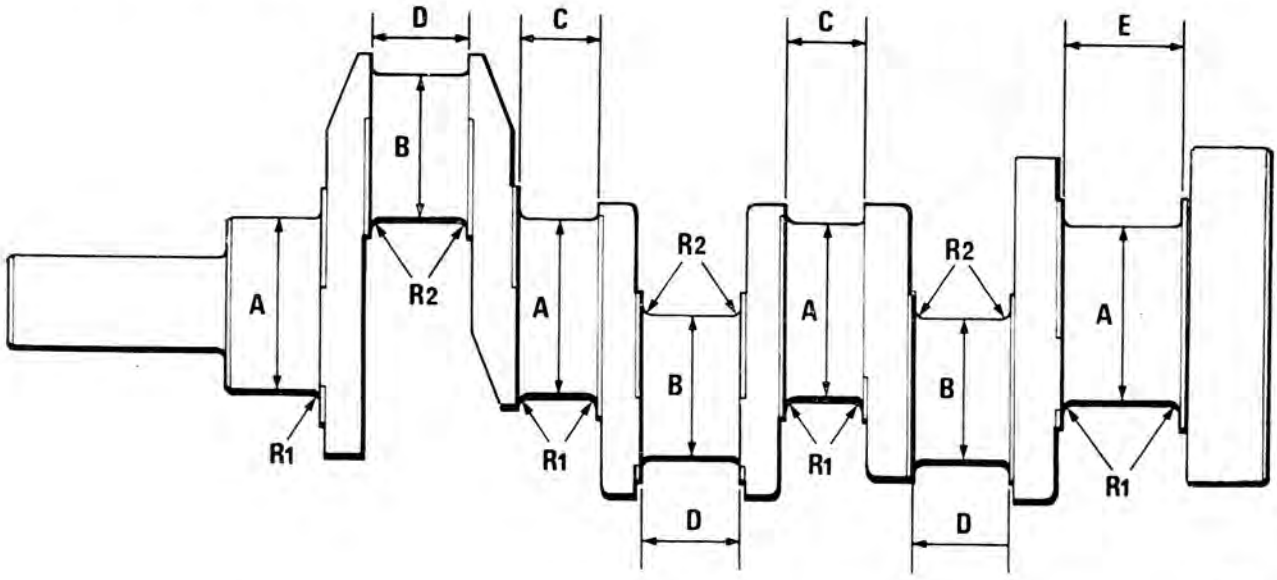
NOTE : Crankshaft Part No. 31312718 or 31313057 is a Tufftrided crankshaft and must be re-Tufftrided after regrinding. If facilities for Tufftriding are not available, then a factory replacement crankshaft should be fitted.

Before proceeding to regrind the crankshaft, the following points should be checked to ensure it is suitable for further machining.

(a) The crankshaft should be crack-detected before regrinding. It must, of course, be remembered to demagnetise the crankshaft after crack-detecting, in order to remove any polarisation which may be present.

(b) The main journal and crankpin diameters should be checked to ascertain the next appropriate size to which the crankshaft can be reground, i.e. —0.010 in (0,25 mm), —0.020 in (0,54 mm), or —0.030 in (0,76 mm). See Fig. H.5.

H.4



H.5

	0.010 in (0,25 mm) Undersize	0.020 in (0,51 mm) Undersize	0.030 in (0,76 mm) Undersize
A	2.7385/2.7393 in 69,56/69,58 mm)	2.7285/2.7293 in (69,30/69,32 mm)	2.7185/2.7193 in (69,05/69,07 mm)
B	2.2384/2.2392 in (56,86/56,88 mm)	2.2284/2.2292 in (56,60/56,62 mm)	2.2184/2.2192 in (56,35/56,37 mm)

C 1.22775 in (31,184 mm) maximum

D 1.575 in (40,00 mm) maximum

E For crankshafts with rope type rear seal — 1.892 in (48,06 mm) maximum

E For crankshafts with lip type rear seal — 1.861 in (47,27 mm) maximum

R1 0.0937/0.1093 in (2,38/2,78 mm) all journals

R2 0.1562/0.1718 in (3,97/4,36 mm) all crank pins

Surface finish of crankpins, journals and fillet radii 16 micro inches (0,4 microns) maximum C.L.A.

Magnetic crack detection D.C. Flow — 2 amps A.C. Current — 1300 amps.

Limits of taper and out of round for pins and journals :

Taper 0.00035 in (0,009 mm) Out of Round 0.0004 in (0,010 mm)

Maximum run-out with the crankshaft mounted on the end main journals :

Independent readings :

Crankshaft Pulley Diameter T.I.R.	Rear Oil Seal Diameter T.I.R.	Flywheel Flange Diameter T.I.R.
0.001 in (0.025 mm)	0.001 in (0,025 mm)	0.001 in (0,025 mm)

Journals T.I.R. — Run-out must not be opposed

Number 1	Number 2	Number 3	Number 4
Mounting	0.002 in (0,05 mm)	0.002 in (0,05 mm)	Mounting

H.6

If the crankshaft requires to be reground below —0.030 in (0,76 mm) it is recommended that a new crankshaft is fitted.

During regrinding, all the limits must be adhered to, and the main journals and crankpins must be free from grinding marks.

Note: It is important that the RADII on the main journals and crankpins are maintained. If these are neglected, a fatigue fracture is liable to occur.

Later crankshafts may be deep rolled, therefore the regrinding of fillet radii will not apply.

After regrinding, the sharp corners on the oil holes should be removed and the crankshaft crack-detected again and demagnetised.

Replacing Crankshaft.

1. Ensure that all oil-ways are clear.
2. Check main bearing setscrews for stretch or damage to threads. Affected setscrews must be scrapped.
   In no case should setscrews other than those supplied by the engine manufacturer be used as they are of special heat treated high-grade steel.
3. Clean bearing housings and place top half bearings in position.
4. Place crankshaft in position.
5. Lightly smear the two upper thrust washers with lubricating oil and slide in recesses provided on either side of the rear main bearing housing, with the steel side of the washers towards the housing.
6. Fit lower halves of main bearings to bearing caps and place in position ensuring that the thrust washers on No. 4 main bearing cap are fitted correctly (See Fig. H.8).

H.7

7. Renew the rear main bearing cap "O" rings (lip seal crankshafts only).
8. Lightly coat the rear main bearing cap butt faces with Perkins (Hylomar) Jointing Compound. For lip seal crankshafts, only coat outboard of the grooves machined in the cap butt faces and ensure that the grooves are free from jointing compound.
9. When replacing the main bearing caps, ensure that they are fitted in their respective positions, also that they are fitted the correct way round. The caps are numbered, No. 1 commencing at the front of the engine. Each cap is also marked with a serial number and when fitted, this number should read in line with the serial number stamped on the cylinder block bottom face (See Fig. H.9).

For final tightening of the setscrews, a torque wrench should be used, set to the tension given on page B.1.

When refitting the crankshaft pulley, ensure that the pulley setscrew is tightened to the correct torque as given on Page B.1. For certain D3.152 applications, the pulley is secured with a $1\frac{1}{2}$ in (38 mm) A/F setscrew and a 0.35 in (8,9 mm) thick washer and this arrangement employs a higher torque than pulleys fitted with a similar setscrew or a $1\frac{1}{8}$ in (29 mm) A/F setscrew and a $\frac{3}{16}$ in (4,8 mm) thick washer.

Re-assemble engine as required and to the instructions given for the various operations.

Rope Type Crankshaft Rear End Oil Seal

The housing consists of two halves bolted around the rear of the crankshaft which has a

shallow spiral oil return groove recessed to a depth of 0.004 to 0.008 in (0,10 to 0,20 mm). The bore of the housing is machined to accommodate a rubber cord asbestos strip. The strip consists of two sections, one for each half of the oil seal housing.

When fitting the seal with the crankshaft in position, the following procedure should be adopted.

1. Set up one half housing in a vice with the seal recess uppermost.

2. Settle approximately 1 in (25 mm) of the strip, at each end, into the ends of the groove ensuring that each end of the strip projects 0.010/0.020 in (0,25/0,50 mm) beyond the half housing joint face. Allow the middle of the seal to bulge out of the groove during this operation.

3. With the thumb or finger press the remainder of the strip into the groove working from the centre. Then use any convenient round bar to further bed in the strip by rolling and pressing its inner diameter. This procedure takes advantage of the friction between the strip and the groove at the ends, to compact the rope, whilst ensuring that the projections of the end faces of the rope remain as set.

4. Fit seal to other half housing in a similar manner.

5. Thoroughly clean the joint and butt faces, removing all traces of the old joint.

6. Lightly coat the cylinder block and cap side of the joint with jointing compound and place the joint in position, ensuring that the securing holes are aligned.

7. Lightly coat the butt faces of the half housings with Perkins (Hylomar) Jointing Compound.

8. Lubricate the exposed inside diameter of the rope seal with graphite grease.

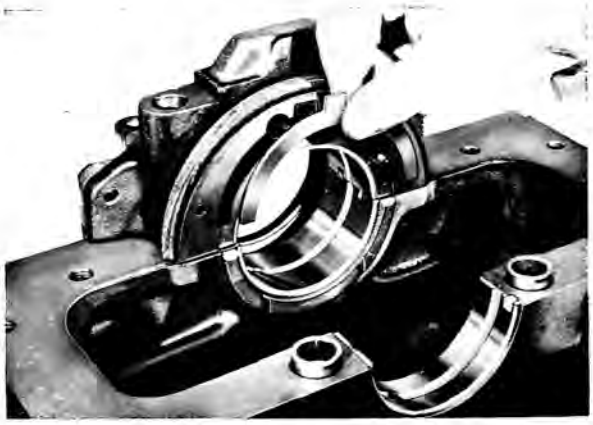
9. Oil the crankshaft rear end around the oil return groove.

10. Place the half housings in position on the engine, ensuring that the half housing with the oil shroud is located in the uppermost position. Locate all setscrews in the cylinder block and bearing cap faces finger tight only.

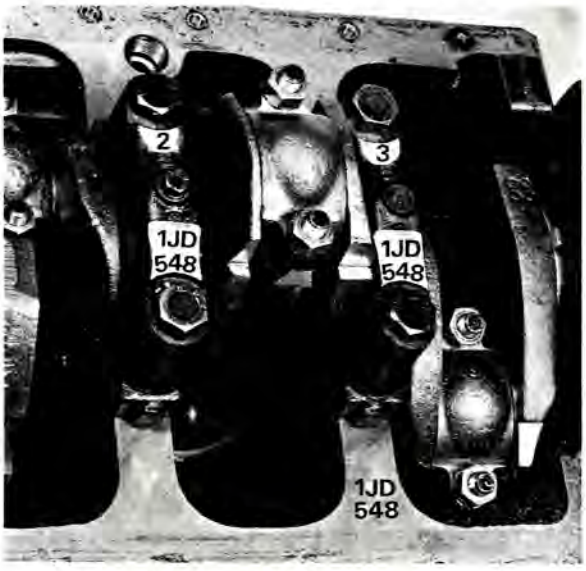
11. Tighten the clamping bolts to a torque of only 6 lbf ft (0,83 kgf m) — 8,13 kN/m².

12. Tighten the setscrews in the cylinder block and bearing cap to a torque of 12 lbf ft (1,66 kgf m) — 16,27 kN/m².

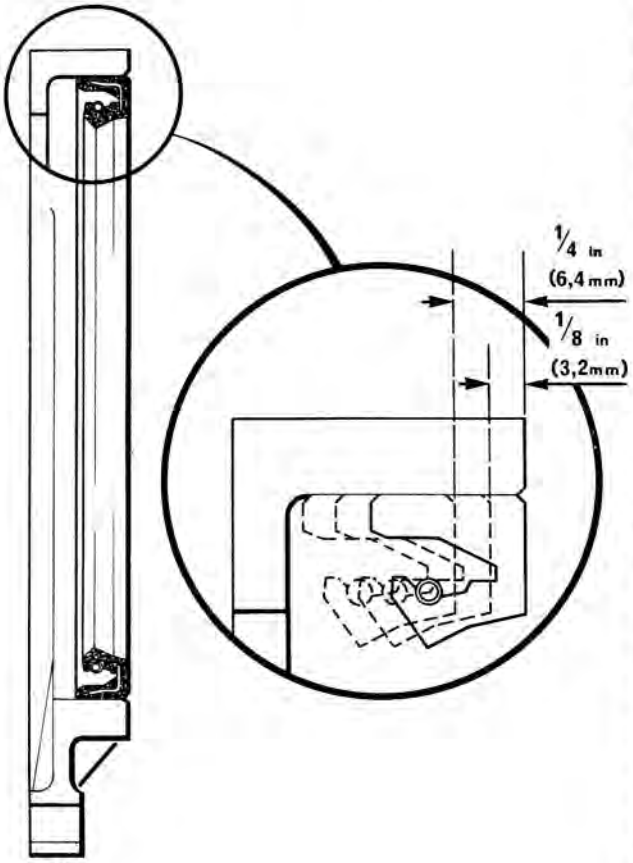
13. Finally tighten the clamping bolts to a torque 12 lbf ft (1,66 kgf m) — 16,27 kN/m².



H.8



H.9



H.10

Lip Type Crankshaft Rear End Oil Seal

On some engines, a circular, spring loaded, lip seal is fitted, which locates on the periphery of the flange of the crankshaft. On production, this seal is fitted with its rear face flush with the rear face of the single piece housing.

This type of seal is easily damaged and extreme care should be taken when handling and fitting it to its housing or to the crankshaft. Any visual damage across the lip of a new seal will cause leakage and prevent bedding in of the new seal.

The seal is designed to function correctly with the direction of rotation of the engine and for identification purposes, the seal is marked with an arrow.

Earlier seals have a flat face as shown in Fig. H.10. Later seals have a protruding dust lip from the rear face as shown in Fig. H.11.

To Fit Lip Seal in its Housing

On production, the old type seal was fitted flush with the rear face of the housing (Fig. H.10) but the new type seal is fitted deeper into the housing at 'A', Fig. H.11.

In service, when a new seal is fitted to a worn crankshaft, it should be pressed further into the housing. In the first instance it can be pressed in to $\frac{1}{8}$in (3,2 mm) for old type seals or position 'B' for new type seals or, if this position has been used, to $\frac{1}{4}$ in (6,4 mm) for old type seals or position 'C' for new seals.

If a new type seal is used in place of an existing old type seal, position 'C' should be used if the old seal was fitted $\frac{1}{8}$ in (3,2 mm) below the housing face.

If all three positions have been used, it may be permissible to machine the worn sealing area of the crankshaft flange (see Page H.3) but not the spigot area on which the flywheel locates. Fig. H.12.

When a new seal is fitted to a new or re-conditioned crankshaft in service, it should be fitted in the production position, but if latest seal is not to be used in a wet back end application, it must be fitted flush with the housing rear face ('D', Fig. H.11).

When pressing in the latest type seal, ensure that the adaptor has a suitable recess to clear the protruding dust lip. Seal guide PD 145C can be used with both type seals.

Before fitting the seal in the housing, carefully examine the seal for damage, especially on the lip and outside diameter.

Using clean engine lubricating oil, lubricate the outside diameter of the seal and the inside diameter of the housing.

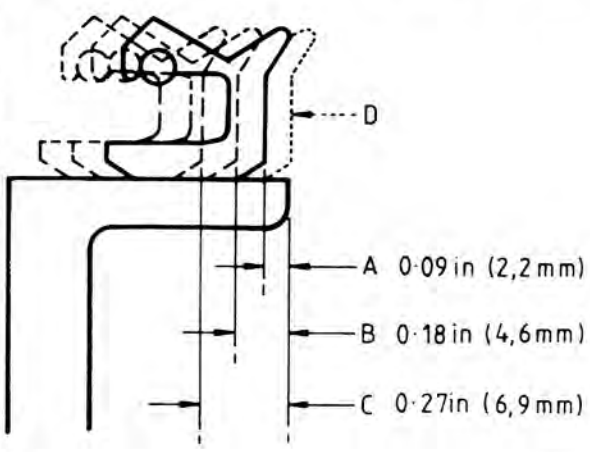
Press the seal into the housing to the required position, taking care that the seal is entered and pressed in squarely, otherwise damage to the outside diameter of the seal may occur, or if it is not square in the housing when fitted to the engine, it may leak.

The seal and housing should be fitted, using seal guide PD 145C (Churchill Tool) as follows :—

Clean the faces of the cylinder block and oil seal housing, and the outside diameter of the crankshaft flange.

Check that the seal and the outside diameter of the crankshaft flange are not damaged. Where a new seal has been fitted, check that it is in the correct position as previously detailed.

Ensure that the two dowels are fitted in the cylinder block. Coat both sides of the joint with Perkins (Hylomar) Jointing Compound and position the joint over the dowels in the block.



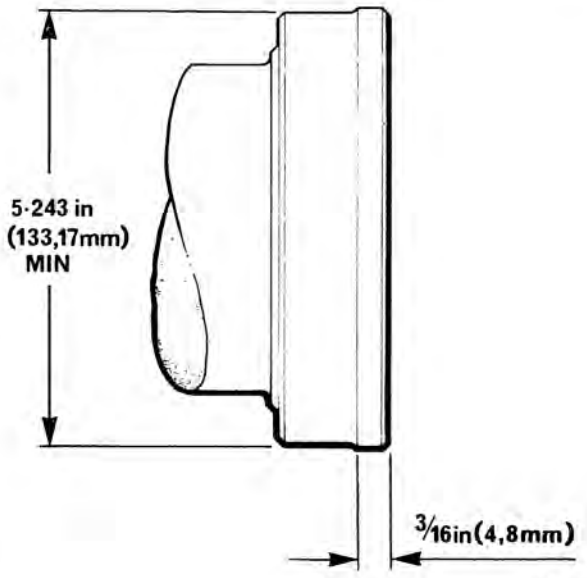
H.11

Using clean engine lubricating oil, lubricate the crankshaft flange, the seal and the seal guide. The lubrication of the seal is necessary to prevent damage that may be caused by initial dry running.

Position the seal and housing on the seal guide, locate the guide on the crankshaft flange and gently press the seal and its housing into position on the flange, locating the housing on its dowels (See Fig. H.13).

Withdraw the guide and secure the housing with setscrews and washers.

The lip type seal assembly and its counterpart crankshaft are not interchangeable with previous types.



H.12

H.13

SECTION J
Timing Case and Drive

The camshaft is carried high up on the off-side of the cylinder block, the construction of which eliminates push rods.

It is driven from the front of the crankshaft by means of gears which also drive the fuel pump.

The timing gears are enclosed by a die-cast timing case cover.

Camshaft Bush No. 1 Bearing

On some D3.152 engines, the No. 1 camshaft bearing housing in the cylinder block is bushed.

A pre-finished bush is available to replace a worn bush. Using a suitable tool and adaptor, the worn bush may be extracted and replaced by a new one, making sure that the oil holes in the bush and cylinder block correspond.

To Remove the Timing Case Cover

1. Slacken the generator mounting bolts and remove the fan belt.
2. Slacken off the hose clips on the hoses fitted to the water pump and remove the water pump.
3. Remove the starter dog and washer, the starter dog is of a normal right hand thread into the crankshaft. Later engines have a setscrew fitted in place of a starter dog.
4. Remove the crankshaft pulley.
5. Remove the engine breather pipe.
6. Remove the generator.
7. Remove the generator brackets and adjustable linkage.
8. Remove the timing case cover setscrews. Two long bolts pass through the timing case to secure a cover at the rear of the timing case, blanking off the power take off bore. In addition to the two long bolts passing through the timing case to secure the generator brackets, a further long bolt passes through the timing case cover, above the position of the generator brackets. The bottom setscrew below the front oil seal is fitted with a copper washer.
9. Remove the timing case cover taking care not to damage the crankshaft front oil seal, which is located in the timing case cover.

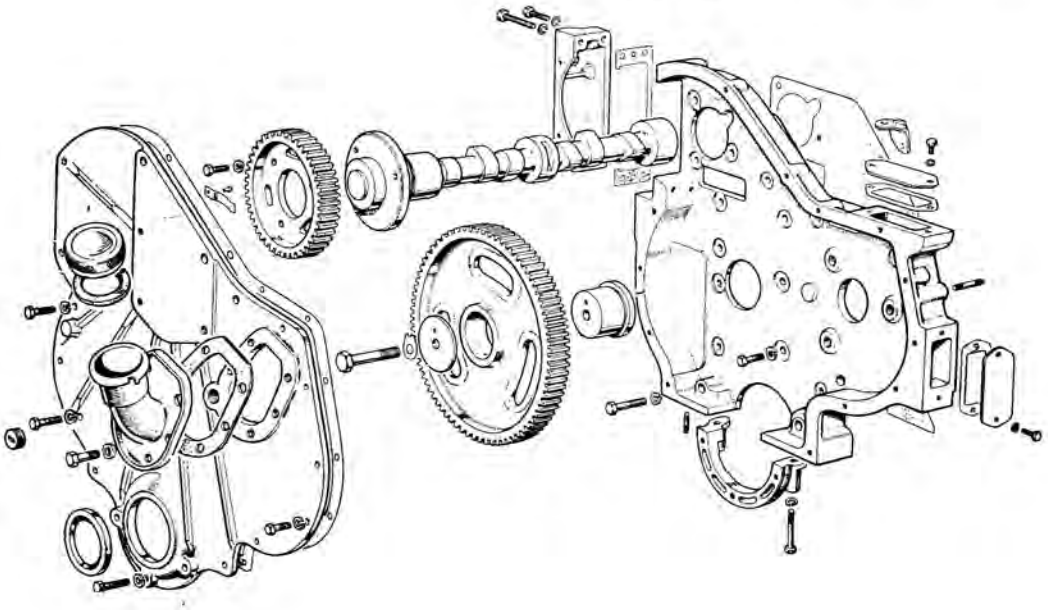
To Renew the Crankshaft Front Oil Seal

NOTE: Earlier engines were fitted with a black nitrile seal and a crankshaft oil thrower.

Later engines have a red silicone seal and the oil thrower is replaced with a distance piece. Under no circumstances should the latest seal be fitted with an oil thrower.

Current engines are fitted with a black 'Viton' type seal. The seal has a protruding lip at the front and the adaptor for pressing in this seal must have a suitable recess in it to clear this lip.

1. Carefully extract the oil seal from the timing case cover using a suitable press.
2. Locate a new seal in the timing case cover with the lip of the seal towards the inside of the cover.



J.2

3. Seals encased with a metal rim should be coated with Perkins (Hylomar) Jointing Compound before being pressed into the timing case cover bore.

4. Tap the new seal in position using a suitable dolly to ensure the seal is square in the bore of the cover

The following depths from the front of the cover should be observed:—(Earlier engines)
3.152 — 0.625 in (15,88 mm)
A3.152
AD3.152 — 0.450 in (11,43 mm)
D3.152 Ag. and Marine—0.469 in (11,91 mm)
D3.152 Ind. — 0.625 in (15,88 mm)

Later engines with black 'Viton' seal :—
3.152 — 0.375 in (9,52 mm)
D3.152 — 0.375 in (9,52 mm)
AD3.152 — 0.375 in (9,52 mm)
D3.152 Marine — 0.465 in (11,81 mm)

To Replace the Timing Case Cover

1. Clean the jointing faces of the timing case and its cover using a new joint, refit the cover and water pump taking care not to damage the front crankshaft oil seal as the cover is entered over the crankshaft front end.

2. For the purposes of centralising the front cover around the crankshaft, position the timing case cover on the timing case by means of two opposite setscrews fitted loosely. Centralise the cover by locating the centralising tool PD 159 on the crankshaft and in the seal housing and tighten the assembly by means of the crankshaft pulley setscrew and washer — do not overtighten.

   Tighten all the timing cover setscrews and nuts and remove tool. If the centralising tool is not available, the crankshaft pulley can be used to centralise the cover but, as this method utilises the inside diameter of the seal and the latest seal is soft, the cover may not be truly central and leaks may occur.

3. Replace the crankshaft pulley, washer and dognut or setscrew.

4. Refit the hoses to the water pump and tighten the clips.

5. Replace the generator bracket, generator and fan belt and tighten the generator retaining bolts.

Timing Gears

The camshaft and the fuel pump gears are driven by the crankshaft gear through an idler gear. All the gears are suitably marked during production to facilitate re-timing, the marks being in line when No. 1 piston is at top dead centre on its compression stroke. It will be appreciated that these timing marks will not align at every rotation of the crankshaft where No. 1 piston is at T.D.C. compression.

If it is necessary to replace any of the timing gears, ensure that there is a minimum backlash of 0.003 in (0,08 mm) — see Fig. J.2.

The backlash between the crankshaft gear and oil pump idler gear should be 0.0075 in to 0.0125 in (0,19 to 0,32 mm. (See Fig. J.3).

J.3

J.4

To Remove the Idler Gear and Hub

1. Turn the crankshaft until the marked teeth of the crankshaft and camshaft gears are in mesh with the idler gear.
2. Bend back the locking washer on the idler gear retaining setscrew, and remove the setscrew, locking washer and idler gear retaining plate.
3. Remove the idler gear from its hub.
4. Remove the idler gear hub from its machined location in the timing case (See Fig. J.4).

To Replace the Idler Gear and Hub

1. Replace the idler gear hub so that the small locating peg is entered into the through drilling in the hub, ensuring the hub is fully located. The flange of the hub should be flush with the timing case.
2. Fit the idler gear on the hub with the long tapered centre boss towards the cylinder block and the timing marks aligned.
3. Replace the idler gear retaining plate, locking washer and retaining setscrew. Fully tighten the setscrew and bend up the locking washer. Ensure that the idler gear has end float on the hub. The end float should be between 0.005 in to 0.015 in (0,13 to 0,38 mm).

To Remove the Camshaft Gear

1. Release and remove the three securing setscrews and shakeproof washers.
2. The camshaft gear may now be removed from the camshaft.

To Replace Camshaft Gear

1. Remove idler gear and release the rocker assembly to facilitate turning of camshaft. On the spigot of the camshaft will be seen the letter "D" stamped adjacent to a fixing hole and on the camshaft gear another letter "D" will also be seen stamped adjacent to a fixing hole (See Fig. J.5). Offer the camshaft gear to the camshaft, ensure the holes with the letter "D" stamped adjacent them are in line. On no account secure the gear to the camshaft by the slotted holes.
2. Replace and secure the three washers and setscrews.
3. Turn the camshaft until Nos. 4 and 6 cams are upright, this can be checked by watching the tappets, and this is the approximate position for aligning timing marks.
4. Fit idler gear, aligning all timing marks and secure the rocker assembly.

To Remove the Fuel Pump Gear

1. Remove the idler gear.
2. Release and remove fuel pump gear securing setscrews.
3. Remove fuel pump gear, taking care not to damage the dowel (See Fig. J.6).

J.5

J.6

To Remove the Fuel Injection Pump

The fuel injection pump is secured to the back of the timing case on the left-hand side of the engine and the fuel pump driving gear is securely attached to the shaft of the pump by three setscrews. The location of the gear to the pump shaft is determined by a dowel.

On the timing case front cover is a small inspection cover forming an oil filter body and strainer. Removal of this oil filter inspection cover gives access to the setscrews securing the driving gear to the pump.

1. Turn the engine to T.D.C. No. 1 cylinder on compression.
2. Remove the fuel pipes to the pump and blank off all ports against the ingress of dirt.
3. Remove the throttle and stop controls from the governor housing of the pump.
4. Remove the oil filler inspection cover from the timing case front cover.
5. Remove the inspection plate from the side of the timing case and wedge the fuel pump drive gear in position to prevent it falling out of mesh when the three securing setscrews are removed. Later engines have a lug in the timing case to prevent the gear from coming out of mesh when the setscrews are removed and in this case, on no account should an attempt be made to turn the engine with the fuel pump removed or damage could result to the gear or lug.
6. Carefully remove the three setscrews and washers securing the gear to the fuel pump, great care must be exercised in removing these setscrews for should one be dropped into the timing case, considerable time and labour would be involved in recovering it (See Fig. J.7).
7. Release and remove the three nuts, plain and spring washers securing the flange of the fuel injection pump to the back of the timing case.
8. Remove the fuel injection pump (See Fig. J.8).

To Replace the Fuel Injection Pump

1. Check that the slot in the fuel pump shaft is in approximate position to the dowel in the gear and offer the pump to the three studs on the back of the timing case and retain with the three plain and spring washers and nuts, but do not tighten the nuts.
2. After ensuring that the dowel in the fuel pump driving gear is located to the slot in the fuel pump shaft, secure the gear to the pump by the three setscrews and locking plate, taking care not to cant the gear to the pump.
3. If necessary, move the fuel pump body until

J.7

J.8

the scribe line on the flange of the pump is in line with the scribe line marked on the back of the timing case.

4. Tighten the three securing nuts.
5. Replace the oil filler inspection cover to the timing case front cover.
6. Replace the throttle and stop controls.
7. Refit all the fuel pipes to the pump.

Where a replacement fuel pump is being fitted, it will be necessary to set the maximum no load speed in accordance with the instructions given on Page N.4.

To Replace the Fuel Pump Gear

1. If necessary fit dowel into fuel pump gear.
2. Replace gear, locating dowel between gear and fuel pump.
3. Replace and secure washers and setscrews.
4. Refit idler gear, aligning all timing marks.

To Remove the Camshaft

1. Remove the rocker shaft assembly as previously described.
2. Remove the timing case cover as previously detailed.
3. Turn the crankshaft until all the timing marks are aligned.
4. Remove the fuel lift pump (See Fig. J.9).
5. Lift the tappets and remove the camshaft and gear from its location in the cylinder block taking care not to damage the journals, cams or tappets (See Fig. J.10).

To Replace the Camshaft

1. Lift the tappets, and carefully fit the camshaft and gear continually turning the camshaft. Take care not to damage the journals, cams or tappets. Make sure the timing marks on the idler gear and camshaft are aligned correctly.
2. Refit the fuel lift pump.
3. Replace timing case cover.
4. Refit the rocker shaft and reset the tappets
5. Replace cylinder head cover.

Camshaft Thrust.

The camshaft end float is taken up by a steel spring rivetted to the timing case front cover.

To Remove the Timing Case.

1. Remove the timing case cover as previously detailed.
2. Release and remove the rocker shaft assembly.
3. Remove the sump as explained under "Lubricating System" (Section L).
4. Remove timing case bottom cover (See Fig. J.11).
5. Unscrew the retaining setscrew and remove the locking washer, idler gear and spigot.
6. Remove the fuel lift pump.

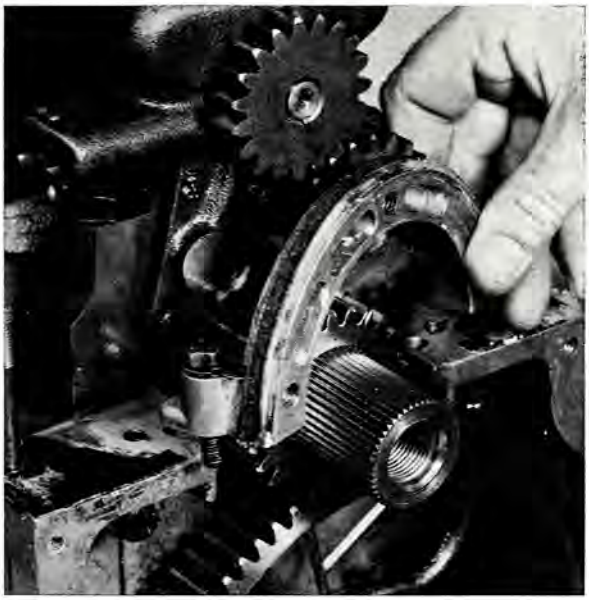
J.9

J.10

7. Lift the tappets and remove the camshatt, complete with its gear, taking care not to damage the cams or bearing journals.
8. Release the three setscrews and remove the driving gear from the fuel pump.
9. Remove all cables and pipes from the fuel injection pump. When removing the high pressure pipes from the pump, release the pipes at the atomiser end and remove the pipes.
10. Unscrew and release the three nuts, spring washers and plain washers securing the fuel pump flange to the timing case and remove the fuel injection pump. Ensure that all inlet and outlet connections of the fuel injection system are effectively sealed against the ingress of dust and dirt by the use of suitable caps and plugs.
11. Remove the setscrews and shakeproof washers securing the timing case to the block and with a light tap remove the timing case from the cylinder block.

To Replace the Timing Case.

1. For the purpose of correct location of the timing case, it is advisable to fit and fully locate the idler gear hub to the cylinder block.
2. Fit a new gasket to the cylinder block front face and replace the timing case.
3. Replace timing case bottom cover ensuring it is correctly aligned with the front face of the timing case (See Fig. J.12).
4. Secure the fuel injection pump to the back of the timing case ensuring the scribed lines on the pump flange and the back face of the timing case are in line.
5. Turn the engine crankshaft until No. 1 piston is at top dead centre (key on the front of the crankshaft vertically upwards)
6. Fit the fuel pump gear to the fuel pump, locating the dowel between the gear and pump.
7. Lift the tappets and replace the camshaft and its gear, turning the camshaft as it is being entered into the camshaft tunnel.
8. Replace the idler gear on its spigot, with the long tapered flange of the gear towards the cylinder block and the timing marks on the crankshaft gear, fuel pump gear, camshaft gear and idler gear in line.
9. Replace the sump as described in the "Lubricating System."
10. Replace the timing case cover.
11. Refit all fuel pipes and controls.



J.11

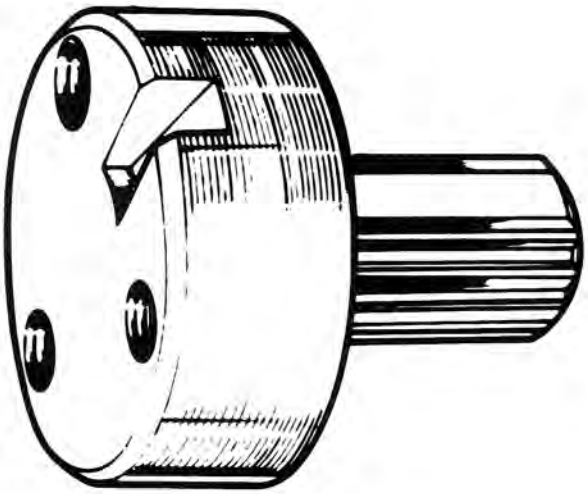
J.12

Fitting New Timing Case

In the event of a new timing case being required, this will not be marked with a scribed line for the correct alignment of the fuel injection pump.

To make this marking with the timing case fitted and with the fuel pump removed, proceed as follows :—

1. Turn the engine until No. 1 cylinder is at T.D.C. on compression by examining the flywheel where the T.D.C. mark should be central within the inspection aperture, or the front of the crankshaft where the key for the fan belt pulley should be at the top of its periphery. Fit the camshaft and idler gears with the timing marks aligned.



J.13

2. Fit Adaptor PD67B-1 (see Fig. J.13) to the fuel pump gear so that the dowel of the gear locates in the slot of the adaptor. Fit the gear with the timing marks aligned and the shaft of the adaptor to the rear of the engine.

3. Release screw (5) of timing tool MS67B (see Fig. J.14) and remove the splined shaft.

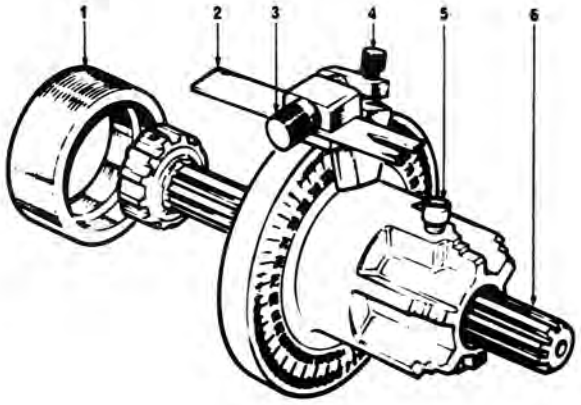
4. Ensure slotted pointer (2) of timing tool is positioned with slot to front of tool and chamfered sides of slot are outwards. At this stage, slotted end of pointer should be kept well back from front of body. Ensure that the flat of washer fitted behind pointer securing screw (3) is located over pointer.

5. Release the bracket locking screw (4) and set bracket so that the chamfered edge is in line with the relevant engine checking angle (see Page B.13).

6. Pressing fuel pump gear and adaptor towards rear, locate splined shaft of adaptor into timing tool with master spline engaged and adaptor shaft in timing tool with rear face of adaptor abutting front face of timing tool.

7. Move tool forward, complete with gear, so that the register of tool locates in pump aperture of timing case. If pointer is 180° out, engine is on wrong stroke and tool should be removed and engine set on correct stroke.

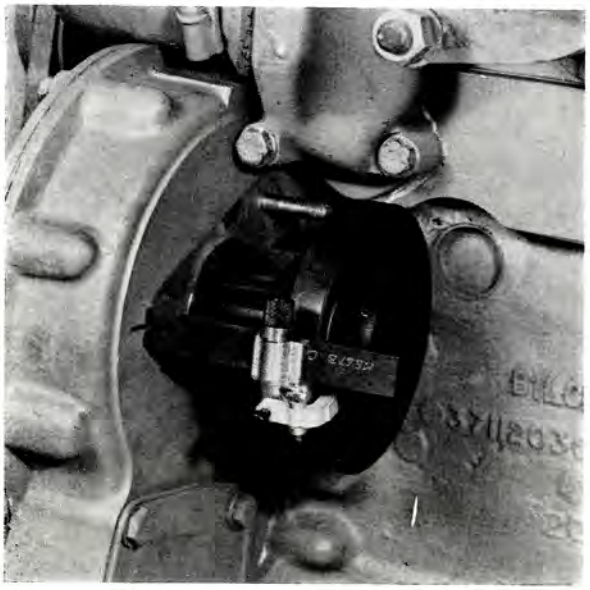
8. Slide slotted pointer forward to rear face of timing case and lock into position.



J.14

9. Take up backlash by turning tool against normal direction of rotation (shown on pump nameplate) and mark the scribed line on the rear of the timing case to coincide with the centre of the slot in the pointer (see Fig. J.15).

10. Remove tool and adaptor from the fuel pump gear and fit the fuel pump to the engine as detailed on Page J.4.



J.15

SECTION K
Timing

K.1

The timing or the resetting of the timing can be simply and quickly carried out if the following instructions are borne in mind.

It is well to remember that the removal of the cylinder head does not in any way affect the timing of the engine.

Timing Marks

When the engine is timed at the factory, certain marks are stamped on the gears, so that if for any reason the timing has to be broken, then the engine can easily be reset to it's original timing.

The method of marking is as follows :—

With the engine timing correctly set, the engine is turned until No. 1 piston is at T.D.C. on its compression stroke. In this position, scribed lines or centre punch marks are marked on the idler gear to correspond with lines or centre punch marks on the camshaft, fuel pump and crankshaft gears respectively (See Fig. K.1).

NOTE :

With all the timing marks aligned, the crankshaft will have to be turned 18 times before all the timing marks will align again.

Fuel Injection Pump Timing Marks

On the fuel pump mounting flange is a scribed line which, when the fuel pump is fitted should coincide with a scribed line on the rear face of the timing case (See Fig. K.2). Providing these scribed lines are in alignment and the fuel pump gear correctly fitted, then the fuel pump timing should be correct.

To Reset Engine Timing

Remove atomisers.

Bring No. 1 piston to T.D.C., No 1 piston being on its compression stroke. That T.D.C. has been obtained can be checked by examining the flywheel where the T.D.C. mark should be central within the inspection aperture, or the front of the crankshaft where the key for the fan belt pulley should be at the top of its periphery.

Fit the camshaft gear ensuring the letter "D" stamped adjacent to one of the fixing holes is in alignment with the letter "D" stamped on the camshaft hub.

Fit the fuel pump gear. This is dowelled and will only go on in one position.

K.2

Check that the fuel pump is correctly fitted to the engine with the scribed line on the mounting flange in line with the scribed line on the rear face of the timing case.

With the crankshaft gear fitted, replace the idler gear ensuring the timing marks coincide (see Fig. K.1).

After testing the engine, final adjustments may be necessary to find the perfect injection point. Adjustment may be made by releasing the fuel pump securing setscrews and turning the pump in the direction required.

To Check Timing

(a) **Valve Timing**

Turn the engine until maximum lift is obtained on No. 3 cylinder exhaust valve.

In this position, set the clearance between rocker lever and No. 1 inlet valve to 0.043 in (1,09 mm).

Now turn the engine in the normal direction of rotation until the tappet of No. 1 inlet valve just tightens.

At this point, No. 1 piston should be at T.D.C. This can be checked by examining the T.D.C. mark on the engine flywheel. The tolerance for valve timing is plus or minus $2\frac{1}{2}°$.

It should be noted that no adjustment is provided for valve timing. Provided the gear is correctly fitted to the camshaft (see previous remarks) then the timing can only be one or more teeth out.

When the timing is found to be correct, adjust the valve clearance to 0.012 in (0,30 mm) cold.

(b) **Fuel Pump Timing**

The circlip used as a timing device in the pump has to be set so that when the appropriate scribed line on the fuel pump rotor aligns with the circlip, it denotes commencement of injection (static timing).

To set the timing circlip, it is necessary to remove the pump from the engine and fix the position of the circlip by connecting No. 1 cylinder outlet connection (marked "W" or "Z") to an atomiser tester and pump up to 30 atm (31 kgf/cm² or 440 lbf/in²). Turn the pump by hand in the normal direction of rotation until it "locks up". The squared end of the circlip should now be adjusted until it lines up with the letter "E" on the pump rotor.

To check the fuel pump timing :—

Ensure fuel pump circlip is correctly positioned as previously described.

Turn the engine in the normal direction of rotation until No. 1 piston is at static timing position B.T.D.C. on its compression stroke.

The relevant static timing position can be ascertained by reference to the service setting code on the fuel injection pump data plate and the table given on Page B.13.

This can be checked by measuring the appropriate distance on the flywheel periphery or by dropping a valve onto the top of No. 1 piston and by means of a clock gauge, checking the piston movement B.T.D.C.

Care is necessary with the latter operation as the consequences of a valve dropping into the cylinder need not be described.

Remove the inspection plate on the fuel pump enabling the rotor to be seen.

With No. 1 piston on static timing point, the scribed line on the fuel pump rotor marked with the letter "E" should be in alignment with the scribed line on the circlip (See Fig. K.3).

On later engines, the circlip bears no scribed line but one end is squared and this end should be aligned with the scribed line on the fuel pump rotor (See Fig. K.4).

The fuel pump gear is dowelled to the fuel pump drive shaft and no adjustment is provided. The only adjustment that can be made is by releasing the fuel pump securing setscrews and turning the fuel pump in the direction required.

K.3

TABLE OF FLYWHEEL DEGREES

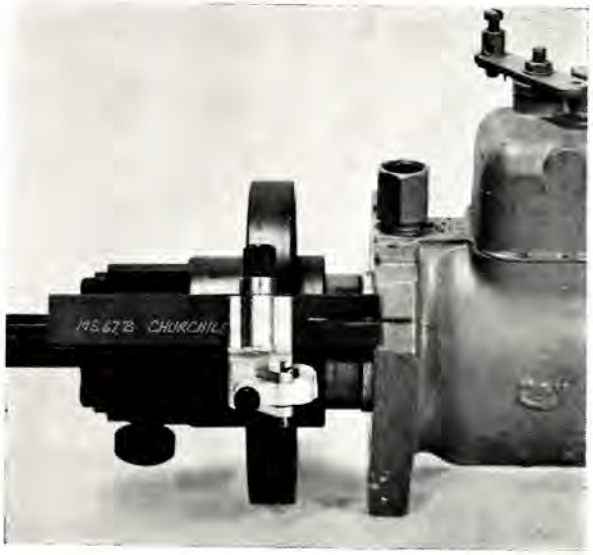
Flywheel Dia.	16°	18°	22°	24°	26°
13½ in (342,90 mm)	1.89 in (48,01 mm)	2.12 in (53,85 mm)	2.59 in (65,79 mm)	2.83 in (71,88 mm)	3.06 in (77,78 mm)
14½ in (368,30 mm)	2.03 in (51,56 mm)	2.28 in (57,91 mm)	2.78 in (70,61 mm)	3.04 in (77,22 mm)	3.29 in (83,55 mm)
14¾ in (374,65 mm)	2.06 in (52,32 mm)	2.32 in (58,93 mm)	2.83 in (71,88 mm)	3.09 in (78,48 mm)	3.35 in (84,99 mm)
15 in (381,00 mm)	2.10 in (53,34 mm)	2.36 in (59,94 mm)	2.88 in (73,15 mm)	3.14 in (79,76 mm)	3.40 in (86,43 mm)
15½ in (393,70 mm)	2.17 in (55,12 mm)	2.43 in (61,72 mm)	2.98 in (75,69 mm)	3.25 in (82,55 mm)	3.52 in (89,31 mm)
16 in (406,40 mm)	2.23 in (56,64 mm)	2.51 in (63,75 mm)	3.07 in (77,98 mm)	3.35 in (85,09 mm)	3.63 in (92,20 mm)

NOTE : It is important to note that the breaking of the seals of the fuel injection pump should only be carried out by authorised personnel who must reseal with suitable indentifiable seals.

K.4

Checking Marking Angle of Fuel Injection Pump using Tool MS67B

1. Release screw (5, Fig. J.14) and position splined shaft with the small splined diameter to the rear to locate in the centre of the fuel pump hub.
2. Ensure that the slotted pointer (2) is positioned with slot to rear of tool and chamfered sides of slot outwards. At this stage, slotted end of pointer should be kept well back towards body of tool. Ensure that the flat in the washer fitted behind the pointer securing screw (3) is located over side of pointer.
3. Release bracket screw (4) and set bracket so that the chamfered edge is in line with the relevant fuel pump marking angle (See Page B.13).
4. Position timing tool with splined shaft in hub, slide tool towards pump to rest on end of hub and lock shaft in tool (See Fig. K.5).
5. Connect No. 1 outlet of pump to an atomiser tester and pump up to 30 atm (31 kgf/cm²) or 440 lbf/in². If pressurising valve is fitted, this must be removed.
6. Turn pump in normal direction of rotation as shown on pump nameplate until it locks.
7. In this position, slide pointer forward until it is halfway over pump flange and check that timing mark is central to slot in pointer.



K.5

SECTION L
Lubrication System

Note : Lubricating oil Data in appendix.

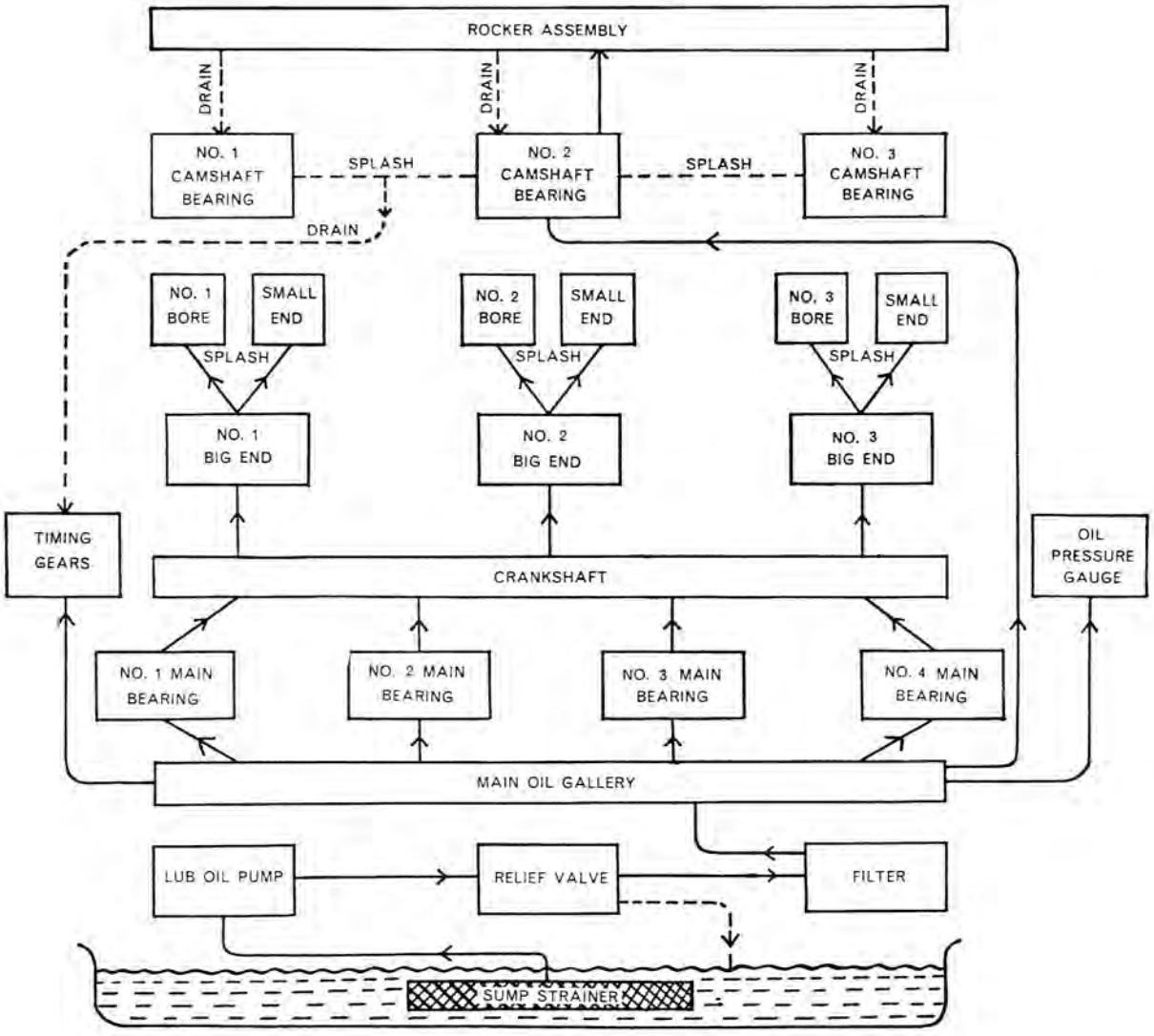
The importance of correct and clean lubrication cannot be stressed too highly and all references to engine oil should be taken to mean lubricating oil which falls within the specifications given in the appendix. Care should be taken that the oil chosen is that specified for the climatic conditions under which the engine is operated.

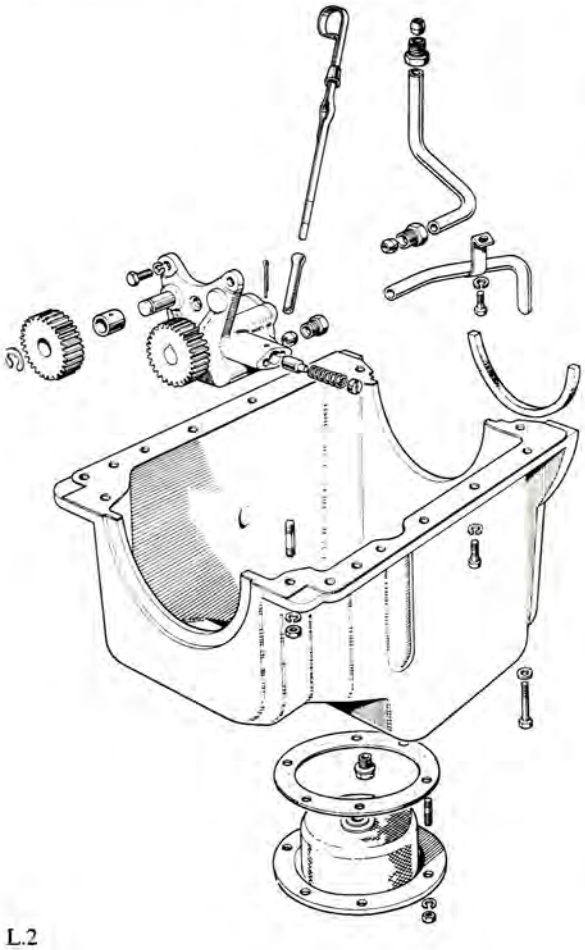
The sump should be filled with a suitable lubricant to the correct level but do not attempt to overfill above the full mark. Before filling or checking the dipstick, ensure the application is on level ground.

Oil Circulation

The system of lubrication (Fig. L.1) comprises pressure feed to main and big end bearings, camshaft bearings, rocker shaft and timing drive.

The pump draws oil through the strainer (where fitted) from the sump and delivers it by a pipe inside the crankcase through a drilling in the side of the cylinder block to the lubricating oil filter





L.2

L.3

Oil passes through the filter and then through an internal drilling in the cylinder block to the pressure rail which is an internal passage within the crankcase.

Holes drilled in the crankcase webs feed oil from the pressure rail to the main bearings and holes in the crankshaft webs carry oil to the big end bearings. Surplus oil returns to the sump.

An oil seal prevents oil leaking along the crankshaft at the rear end and oil thrown from this seal returns to the sump.

The small end bushes are lubricated by splash and lubricating oil mist.

Running across the front of the cylinder block is an internal passage which connects with the pressure rail. The oil comes out from this passage on the camshaft side of the engine and is delivered along an external pipe to the lower drilling in the centre camshaft bearing journal. With a number of engines, this feed is also taken externally to the front camshaft bearing.

As the camshaft revolves, oil is picked up and carried round in the narrow slot machined on the centre camshaft journal until it escapes through the upper drilling in the camshaft tunnel. The oil then flows through a pipe to the cylinder head whence another pipe conveys it to the hollow rocker shaft which feeds oil to the rocker lever bushes, etc.

It will be appreciated that owing to the small capacity of the slot on the camshaft journal, only a reduced quantity of oil can pass to the rocker shaft during each revolution of the camshaft.

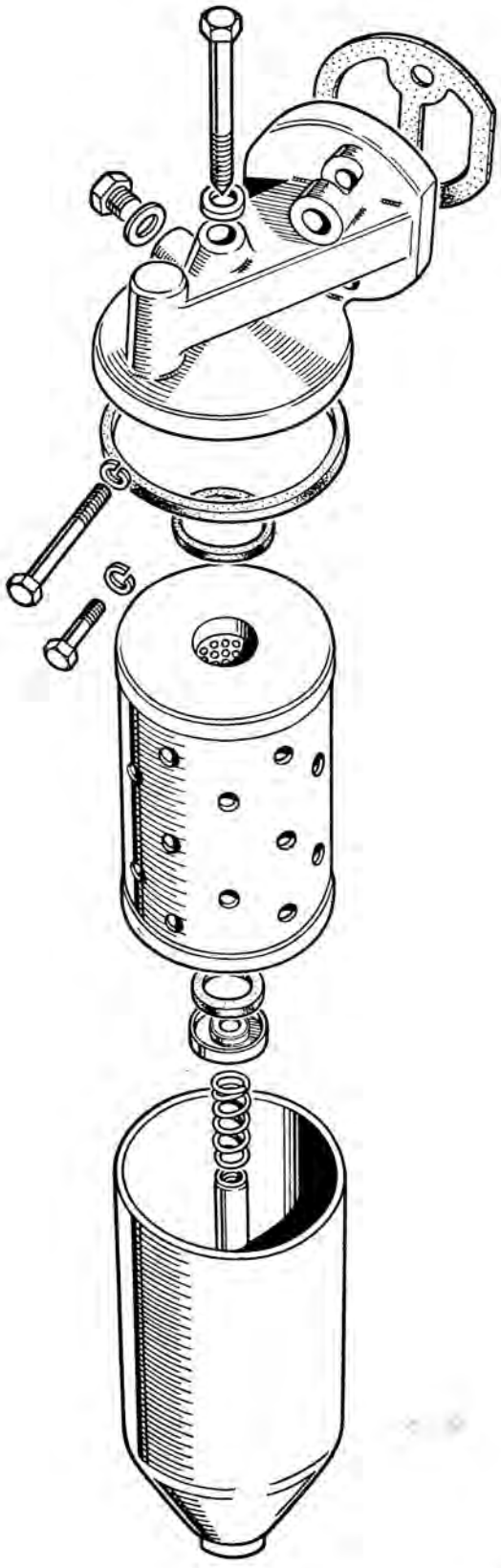
The overflow of oil from the rocker shaft flows from the cylinder head into the camshaft tunnel and from the front of the tunnel on to the timing gears and then returns to the sump.

Further lubrication for the timing gears is provided by means of a drilling in the block between the horizontal drilling referred to previously and the idler gear spigot. Oil from this drilling escapes through a hole in the idler gear boss.

Oil Pressure

See that oil pressure is registered on the gauge

The actual pressure may vary with individual engines but the oil pressure at maximum engine



L.4

speed and normal working temperature should be 30/60 lbf/in² (2,1/4,2 kgf/cm²) or 207/414kN/m².

There will be a pressure drop whilst idling and a slight decrease in normal working pressure when the engine is hot.

If the oil pressure as registered on the gauge is below normal, check the following in the order given below.

1. Dipstick. Ensure the sump oil level is up to the "full" mark.
2. Oil pressure gauge. Check for accuracy with master gauge.
3. Lubricating oil filter. May be choked. Renew element or canister (See Page L.4).
4. Sump strainer if fitted. May be choked. Remove, clean and replace (See Page L.5).
5. Lubricating oil pump. Ensure that suction and delivery pipe unions are tight.
6. Oil pressure relief valve. Foreign matter may be preventing valve from closing.

LUBRICATING OIL FILTERS

The importance of using clean lubricating oil in the first place, and providing means to ensure that it is always clean in use, is hardly second to the importance of cleanliness in respect of the fuel.

It is imperative, therefore, that lubricating oil filters are not neglected. Moreover, if the periodical attentions herein recommended are carried out and the correct grade of clean oil used, a very long life can be obtained from the Perkins engine.

To ensure cleanliness, filters are incorporated.

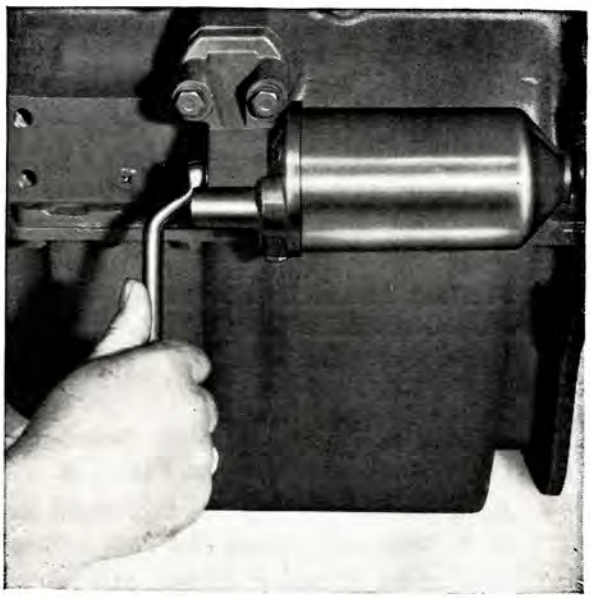
This strainer requires no special attention, but it should be cleaned every time the sump is removed. On some engines, the strainer is attached to a removable cover at the bottom of the sump, as shown in Figs. L.2 and L.3.

Main (Full Flow) Filter

This filter incorporates either a separate paper element fitting in a filter bowl (Fig. L.4) or a screw-on canister where the element is integral with the canister. Both elements should be renewed — not cleaned, at the appropriate time, as given in Section C.

To Renew the Paper Element :—

1. Unscrew the centre bolt at end of cover (See Fig. L.5).
2. Drop filter bowl clear (See Fig. L.6).



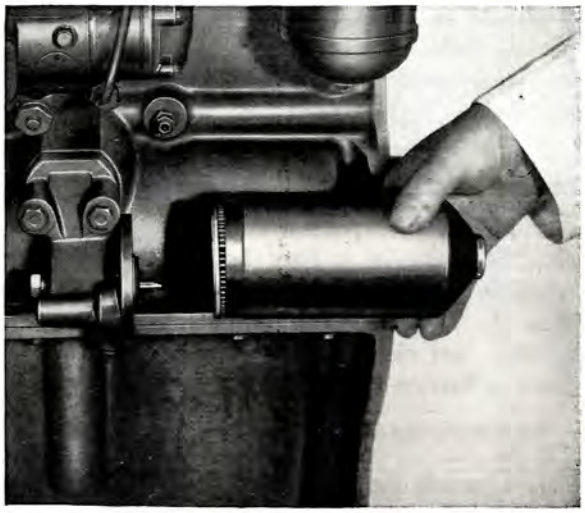
L.5

3. Remove element and discard.
4. Before replacing new element, clean inside of filter bowl with cleaning fluid.
5. Ensure that the felt washer and rubber joints are in good condition, if not, replace by new.
6. Start engine and check for leaks. Check oil level after running and top up as necessary.

The bolt securing the filter bowl should be checked for tightness after the first 25 hours of running.

To Renew the Canister :—

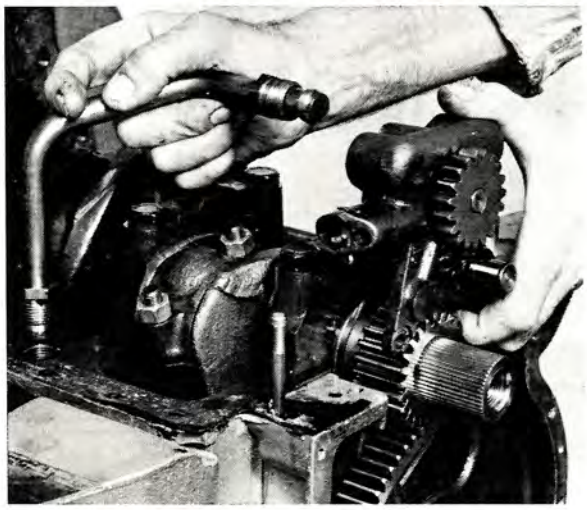
1. Unscrew and discard old oil canister (See Fig. L.7).
2. Clean the filter head and the threaded adaptor.
3. Using clean engine lubricating oil, liberally oil the top seal of the replacement canister.



L.6

L.7

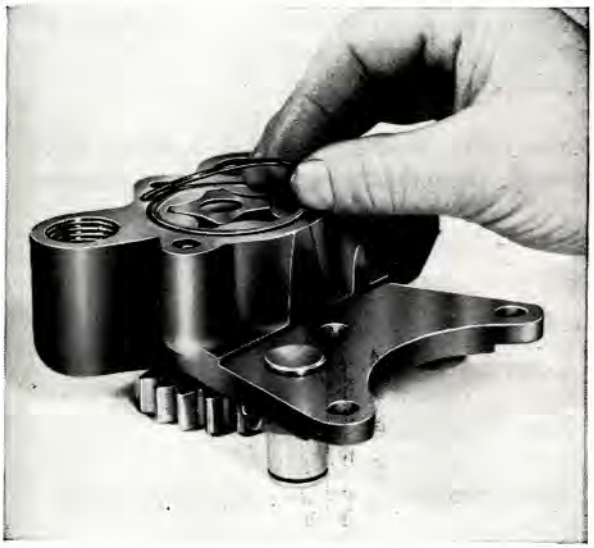
4. Fill the new canister with clean lubricating oil, allowing time for the oil to filter through the element. Screw the replacement canister on to the filter head until the seal just touches the head and then tighten by hand as detailed in the instructions on the canister. Where a tool is available, tighten to 15 lbf ft (2,07 kgf m) or 20 Nm.



L.8

5. Run the engine and check for leaks. Check the oil level after running and top up as necessary.

   Note : The oil filter canisters have internal valves to prevent drain back and a special tube stack is fitted, so always ensure that the correct replacement is used.



L.9

Oil Pressure Relief Valve

The oil relief valve which is located in the oil pump body prevents the pressure becoming excessive as might otherwise happen when the oil is cold.

The relief valve comprises a spring loaded plunger.

When the pre-determined pressure setting is exceeded, the valve opens and some of the oil is released to return to the sump. That continues until the oil warms up and flows at the desired pressure. The valve then closes.

When to Renew the Oil

The oil in the sump must be drained in accordance with preventive maintainance, page C.3, and replaced by clean new oil of a specification suitable for the climate (See Appendix).

To Remove, Clean and Replace Sump Strainer

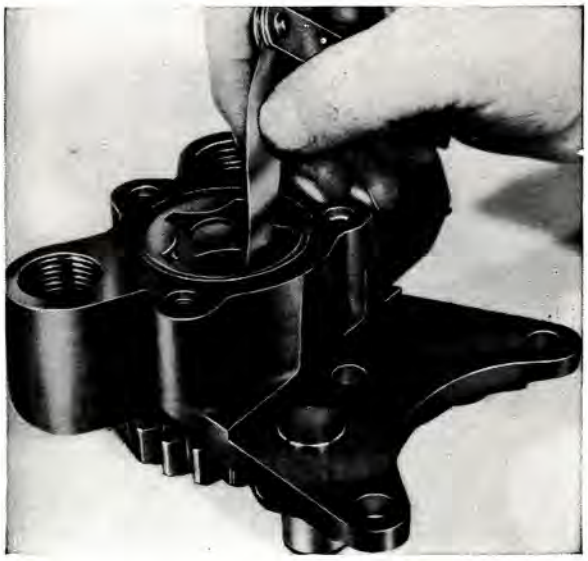
Remove sump drain plug and drain oil into suitable receptacle.

Remove nuts holding sump strainer cover to bottom of sump.

Drop cover to which the sump strainer is attached (See Fig. L.3).

Wash and clean strainer in clean fuel oil or paraffin.

To re-assemble, reverse the order of operations. Ensure that the oil pump suction pipe enters the hole provided in the strainer.



L.10

If reasonable care is taken when removing and replacing the sump strainer cover, the joint will not require renewing every time the strainer is removed.

Note : On some engines, it is necessary to remove the sump to gain access to the sump strainer.

To Remove Sump

Remove drain plug and drain off oil.

Remove dipstick.

Remove sump strainer (see previous heading).

Where necessary, remove setscrews securing rear of sump to flywheel housing.

Remove all setscrews securing sump to crankcase and lower sump.

To Replace Sump

Remove all traces of old joints and cork strips from timing case bottom cover and rear main bearing cap.

Lightly smear crankcase faces with a thin coating of jointing compound and place joints in position ensuring all holes line up.

L11

When placing joints in position, it is important that the mitred ends go right up into the recesses of the timing case bottom cover and rear main bearing cap.

Lightly coat cork joints with jointing compound and place in the grooves provided in the timing case bottom cover and rear main bearing cap.

Place sump in position and screw setscrews lightly home.

Where applicable, replace setscrews securing rear of sump to flywheel housing.

Tighten setscrews securing sump to crankcase.

Replace sump strainer with cover plate ensuring the suction pipe enters the hole provided.

Replace dipstick and sump drain plug.

To Remove Oil Pump.

Remove sump (see previous heading).

Remove the three setscrews at the bottom of the timing case front cover and the two nuts at the bottom of the timing case when the timing case bottom half can be removed.

Disconnect the delivery pipe from the oil pump to cylinder block.

Remove circlip and move idler gear forward.

Unscrew the three setscrews securing the oil pump to the front main bearing cap and remove oil pump. (See Fig. L.8).

To Dismantle Oil Pump.

Remove suction and delivery pipes.

Remove idler gear.

Using a special screwdriver, unscrew the three screws and remove the pump end plate.

L.12

Remove the rubber sealing ring (where fitted) (See Fig. L.9.).

The outer rotor can then be removed.

The oil relief valve is located in the body of the lubricating oil pump. It is an adjustable valve but unless special test equipment is available, no attempt should be made to dismantle it. The breaking pressure is set and adjusted before the engine leaves the works.

Inspection.

The clearances for new pumps are given in Section B.

1. Thoroughly clean all parts and inspect the rotors for cracks or scores.
2. Install the driven rotor in the pump body making sure the chamfered edge of the outer rotor enters the pump body first. Check the clearance between the maximum diameter of the inner rotor and the minimum diameter of the outer rotor at all points (See Fig. L.10).
3. Check the clearance between the driven rotor and the pump body (See Fig. L. 11).
4. Check the clearance between the top of the rotors and the end of the pump body with feeler gauges and straight edge (See Fig. L.12).

NOTE : Should an oil pump be worn to such an extent it adversely effects the working oil pressure then a replacement pump should be obtained. The component parts of the oil pump are not supplied individually therefore if any parts require replacing a replacement assembly should be fitted.

To Re-assemble the Oil Pump

Replace outer rotor in oil pump body.

Renew rubber sealing ring (where fitted).

Replace end cover and secure with three screws.

Replace idler gear.

To Refit Oil Pump

Prime lubricating oil pump with oil before fitting.

Fit oil pump to front main bearing cap and secure with three setscrews.

Secure idler gear with circlip.

Replace suction and delivery pipes to and from oil pump.

Replace timing case bottom half and secure with two nuts and washers to timing case top half.

Replace the three setscrews at the bottom of the timing case front cover.

Replace sump in accordance with previous instructions.

Before starting, the engine should be turned over whilst operating the stop control, until oil pressure is registered.

SECTION M
Cooling System

The cooling water is circulated by a centrifugal type pump which is mounted on the front of the timing case cover. It is driven by a Vee-belt from the engine crankshaft and provision is made for fitting a fan on the front end of the water pump pulley.

The pump does not require greasing as the bearings are treated with a special quality grease before assembly.

Fan Belt Adjustment

Belt tension should be adjusted so that, without undue pressure, the belt can be depressed approximately $\frac{3}{8}$ in (10 mm) with the thumb applying pressure at a point midway between the water pump and generator pulleys (Fig. M.1).

Adjustment of the belt tension is achieved by altering the position of the generator. Release the generator adjusting link and support bracket bolts, move the generator to give the correct tension and then tighten the bolts and recheck the tension.

When a new belt has been fitted, it is advisable to check the belt tension after a few hours running to ensure that no initial stretching has occurred.

To Remove Water Pump

Remove fan.

Slacken dynamo securing setscrews and remove fan belt.

Remove water pump inlet and outlet hose connections.

Unscrew nuts and setscrews securing the water pump to back-plate and remove water pump.

To Dismantle Water Pump

Remove the water pump pulley using a suitable tool (See Fig. M.3). The tapped holes in the pulley can be utilised for this purpose.

Press the water pump shaft complete with bearings and impeller from out of the rear of the pump body. Press the shaft and bearing assembly out of the impeller.

Remove the ceramic counterface, seal and thrower from the shaft.

The shaft and bearings are manufactured as one component and cannot be dismantled.

To Re-Assemble Water Pump

With the shorter end foremost, press the shaft and bearing assembly into the rear of the water pump body until the bearing housing end is flush with the front of the water pump body.

Replace the water thrower.

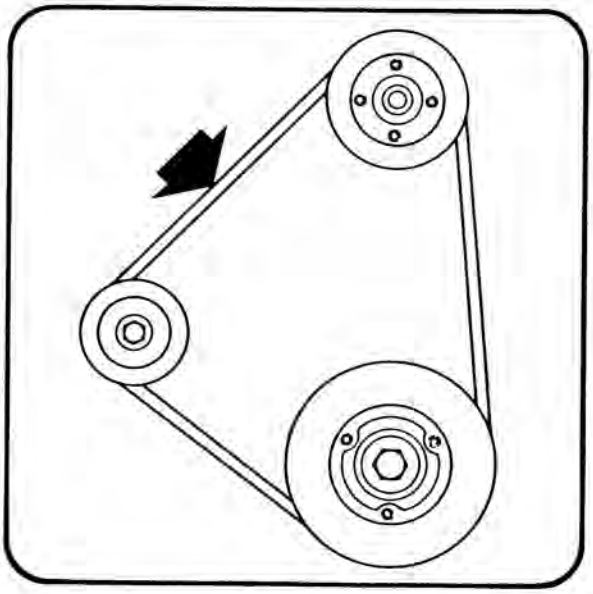
Fit the seal with the sealing face to the rear and the flange against the machined face of the body.

Fit the ceramic counterface seal to the shaft with the ceramic insert towards the seal.

Supporting the shaft at the front end, press the impeller with blades inwards onto the rear of the shaft until a dimension of 0.010 in (0,25 mm) to 0.020 in (0,51 mm) is obtained between the blades of the impeller and the pump body, (See Fig. M.4).

Spin the assembly to ensure freedom of rotation.

Supporting the shaft at the impeller end, press on the water pump pulley until the front end of



M.1

the pulley is flush with the front end of the shaft, where the fan mounting face is projected forward (Fig. M.5), press the pulley on until the fan mounting face is 5.531 in (140,49 mm) from the rear face of the pump body.

Recheck the clearance between the impeller blades and pump body, and spin the assembly to ensure freedom of movement.

Note: Where a water pump is fitted with a ceramic seal and the engine is run without coolant in the water pump, the heat build-up between the carbon seal and the ceramic counter face is very rapid, resulting in the cracking of the ceramic.

This can cause a misunderstanding that the leakage of water from the pump is due to the incorrect assembly of the sealing arrangement in the water pump.

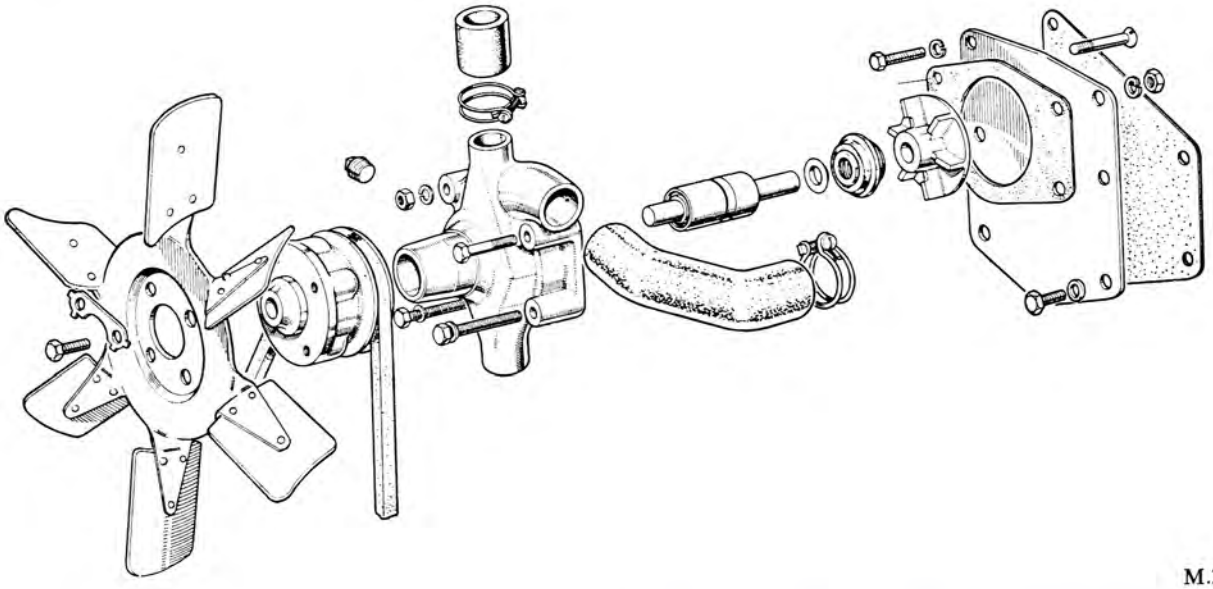
To Re-fit Water Pump to Engine

Fit new water pump joint, using jointing compound.

Fit water pump to back-plate and secure with nuts and setscrews.

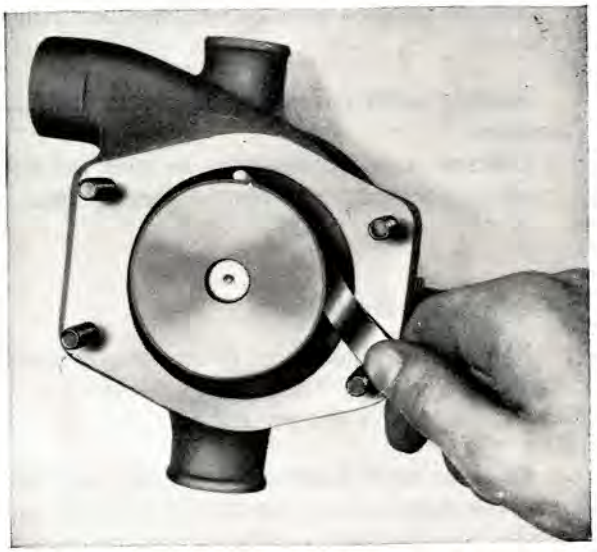
Connect up water pump inlet and outlet hose connections.

Replace fan belt and tension (see page R.1).
Replace fan.



M.2

M.3

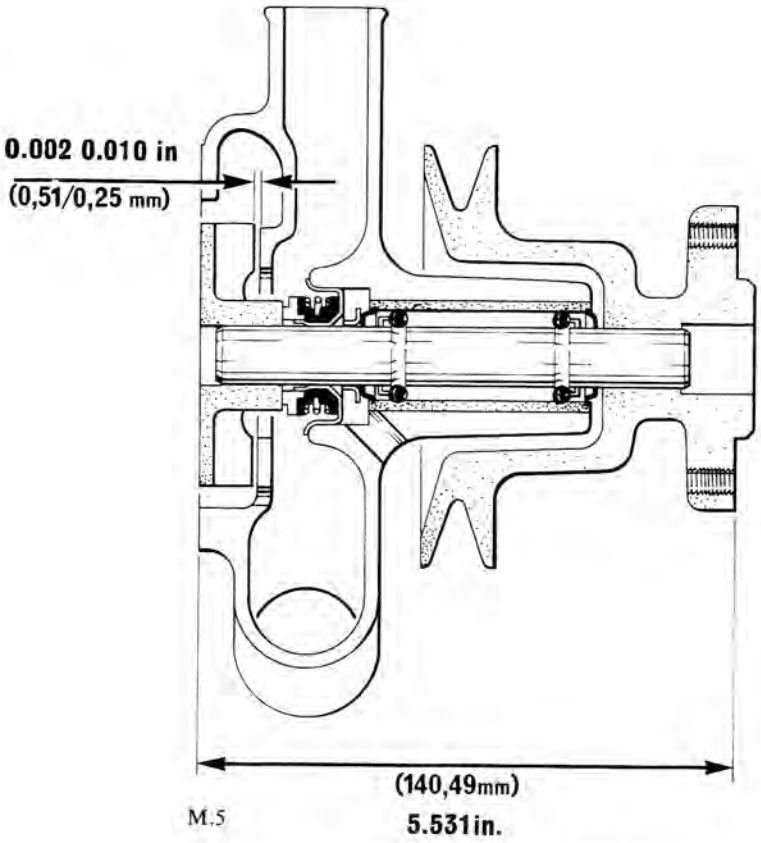


M.4

Thermostat

A thermostat is fitted in the cylinder head water outlet to assist in providing a shorter warming up period for the engine. The thermostat can be removed after the water outlet connection and joint have been removed. When refitting the thermostat, ensure that the jiggle pin in the top of the thermostat is free to move in its location or the bleed hole is clear.

To check the thermostat, suspend it in water and heat gradually. With a thermometer, check that the thermostat operates at the temperatures given in Section B. If it is faulty, it should be renewed — no attempt should be made to adjust a faulty thermostat.



M.5

Pump with Forward Projected Fan Mounting.

SECTION N
Fuel System and Air Cleaners

The principal components of the equipment for delivering the fuel oil to the engine cylinders are as follows :

Filters.
Fuel lift pump.
Fuel Pump.
Atomisers.

The fuel lift pump "lifts" the fuel from the tank to the fuel pump which conveys it in measured quantities, and at appropriate intervals, to the atomisers.

The normal course of the fuel from the tank to the engine is by way of : first, the fuel pre-filter, then the fuel lift pump ; then the final fuel filter ; the fuel pump and the atomisers.

Two conditions are essential for efficient operation.

First, that the fuel oil should be clean, free from water, suspended dirt, sand and other foreign matter and should conform to one of the specifications given in Section B.

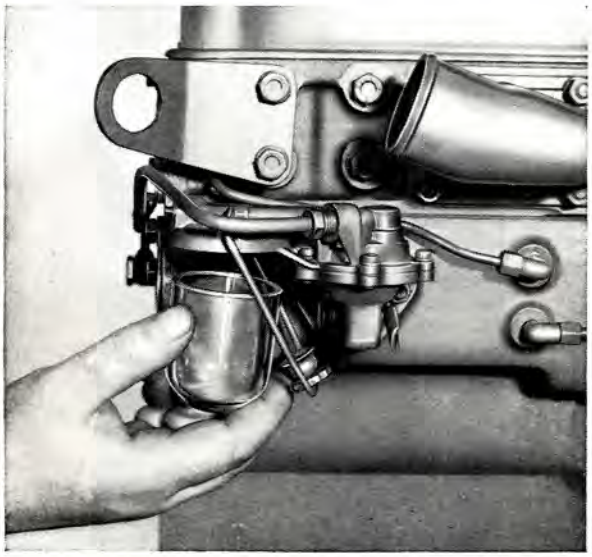
Second, that the fuel reaches the fuel pump in a perfectly clean state.

Fuel should be filtered before entering the tank.

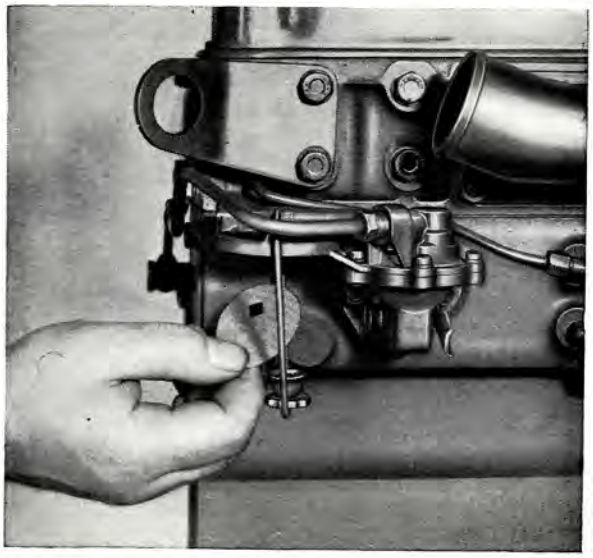
FUEL OIL FILTERS

Great care has been taken in the design of the engine to ensure that only clean fuel oil reaches the fuel pump.

Fuel oil filters are provided as well as a dirt trap in the fuel tank.



N.1



N.2

The first filter is a gauze trap in the filler of the fuel tank. This must not be removed when fuel is being poured into the tank.

It should be taken out every 400 hours, cleaned, washed in cleaning fluid and immediately replaced.

If there is no filter in the filler, the fuel should be poured through a fine gauze strainer when filling the tank.

N.3

N.4

The second filter consists of a water trap in the form of a glass bowl mounted adjacent to the fuel lift pump or as a separate unit fitted in the fuel line upstream of the lift pump.

This pre-filter should be dismantled (See Fig. N.1) and the gauze strainer cleaned (See Fig. N.2) in accordance with the Preventive Maintenance quoted in Section C unless the condition of the fuel warrants more regular attention.

After cleaning, ensure that good joints are made when re-assembling this filter as any leakage of air here may cause air locks in the fuel system.

On certain engines, an intermediate fuel filter is fitted and is identical with the following final fuel filter.

The third and final filter is a paper element type filter. It is not possible to clean the paper element. It should be renewed every 500 hours.

To Renew the Element (current engines)

1. Unscrew the bolt in the centre of the top filter cover (See Fig. N.3).
2. Drop filter bottom cover clear (See Fig. N.4).
3. Remove the element and discard.
4. Before putting the new element into position, clean the filter top and bottom covers.
5. Ensure that the rubber joints are in good condition, if not, replace with new joints.

After re-assembling the filter, the system should be bled as instructed later.

Alternative Final Fuel Filter (early engines)

The alternative type final fuel filter also contains a paper element which should be renewed at 500 hours.

With this type of filter, the filter bowl securing bolt is accessible from the bottom of the filter bowl and a vent plug is provided in the filter head.

To Renew the Element

1. Unscrew the bolt at the bottom of the filter bowl.
2. Drop the filter bowl clear.
3. Remove the element and discard.
4. Before putting new element in position, clean filter bowl.
5. Ensure that the washers and joints are in good condition, if not, replace by new.

In common with the other type filter, the fuel system should be bled as instructed below.

Bleeding the Fuel System

In the event of air entering the fuel system, it will be necessary to bleed the system to remove it. Air can enter the system as a result of running out of fuel, leaks in the system, changing filter elements or disturbance of fuel connections.

To bleed the system, proceed as follows :—

1. Slacken the air vent screw on the side of the governor control cover of the fuel injection pump (see Fig. N.5).

N.5

N.6

2. Slacken vent screw on one of the two hydraulic head locking screws on the side of the fuel pump body (see Fig. N.6).
3. Slacken the vent plug on the top of the final fuel filter, (where fitted).
4. Operate the priming lever of the fuel lift pump (see Fig. N.7) and when fuel free from air bubbles, issues from each venting point, tighten the screws in the following order :—
   (a) Fuel filter (where fitted).
   (b) Head locking screw.
   (c) Governor vent screw.
5. Slacken the pipe union nut at the fuel pump inlet (See Fig. N.8). Operate the priming device and retighten when fuel oil, free from air bubbles, issues from around the threads.
6. Slacken the unions at the atomiser ends of two of the high pressure pipes.
7. Set the accelerator at the fully open position and ensure that the "stop" control is in the "run" position.
8. Turn the engine until fuel oil, free from air bubbles, issues from both fuel pipes.
9. Tighten the unions on both fuel pipes and the engine is ready for starting. If the fuel has been drained from the thermostart feed pipe, the pipe must be disconnected at the thermostart and all air bled from the pipe before the thermostart is operated.

The Fuel Lift Pump

The lift pump is of the diaphragm type. It is fitted to the side of the camshaft tunnel and is driven by an eccentric on the engine camshaft.

A hand primer is fitted for use if the supply of fuel from the tank has at any time failed.

The lift pump illustrated in Fig. N.9 has an integral pre-filter fitted but, on later engines, the pre-filter is separate.

To use this primer, pump by hand until pipes, lift pump, filters and fuel pump are full of fuel oil.

Testing the Lift Pump Fitted to the Engine

Disconnect the outlet fuel pipe.

Rotate the engine, or operate the hand priming lever. A spurt of fuel should emit from the outlet

N.7

N.8

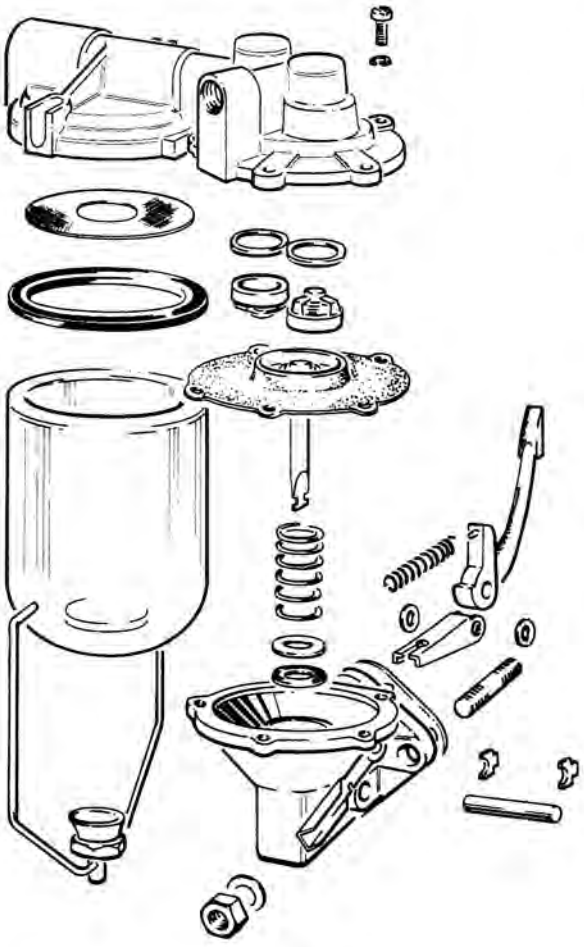
port once every two engine revolutions, or every time the hand priming lever is depressed.

NOTE: If the hand lever cannot be depressed, rotate the engine one complete revolution in order to turn the eccentric on the camshaft from its maximum lift position.

Pressure Checking of Fuel Lift Pump in Position

Fit a 0 - 10 lbf/in² (0 - 0,7 kgf/cm²) or 0 - 70 kN/m² pressure gauge to the outlet of the pump. Ensure that there are no leaks at the connections between pump and gauge. Crank the engine for ten seconds and note the maximum pressure on the gauge. If the pressure recorded is less than 75% of the minimum production static pressure shown below, then rectify the pump. Also observe the rate at which the pressure drops to half the maximum figure obtained when cranking has ceased. If less than thirty seconds, rectify the pump.

Minimum Production Static Pressure			Minimum Test Pressure (75% of Minimum Production Pressure)		
lbf/in²	kgf/cm²	kN/m²	lbf/in²	kgf/cm²	kN/m²
6	0,42	41	4.5	0,31	31



To Remove the Lift Pump

Disconnect the fuel pipe, from the inlet and outlet ports.

Remove the nuts and spring washers which secure the pump to the cylinder block, and withdraw the pump (See Fig. J.9).

To Dismantle the Lift Pump

Remove the water trap, where necessary, by unscrewing the knurled nut at the bottom of the glass bowl, and remove the gauze strainer.

Before dismantling, make a file mark across the two flanges for location purposes when the pump is being reassembled. Remove the five cover screws and separate the two main parts, then remove the diaphragm assembly from the lower half by turning the diaphragm through 90° in either direction.

The valves are "staked-in", and can be prised out by using a screwdriver or other suitable tool. Clean the casting so that new valves can be correctly seated. Press valves into position using a suitable "dolly". Stake the casting around the valves in six places.

The rocker arm pin can be removed by securing the rocker arm in a vice, and tapping the face of the body with a soft mallet until the retainers are dislodged. The rocker, pin, lever and return spring can now be examined for wear.

To Re-assemble the Lift Pump

Fit the rocker arm assembly into the bottom half of the lift pump. Fit the rocker arm return spring making sure that it seats properly.

Tap new retainers into the grooves in the casting, and stake over the open ends of the grooves.

Place the diaphragm assembly over the spring, with the pull rod downwards, locating the top of the spring in the diaphragm protector washer. Position the rod so that the notched blade locates into the rocker arm link. Press downwards on the diaphragm assembly so that the notches on the pull rod align with the rocker arm link and twist it through 90° in either direction, this action will engage and retain the pull rod in the fork of the link.

When re-assembling the two pump halves, push the rocker arm towards the pump until the diaphragm is level with the body flanges. The cover assembly can now be placed in position, with the file marks aligned. Maintaining the pressure on the rocker arm, fit the securing screws and washers and tighten evenly.

Where necessary, replace the gauze strainer and water trap, ensuring that an air tight joint is made.

To Refit the Fuel Lift Pump

Ensure that the pump flange and cylinder block pump mounting face are clean, and using a new joint, enter the pump operating lever into the aperture in the block. Fit the pump onto the mounting studs and secure with nuts and spring washers.

Fuel Injection Pump

The fuel pump is of the distributor type. Its working parts are made to extremely fine limits and mishandling in any shape or form, or the entry of the smallest particle of dirt into its working parts may damage it and diminish its accuracy of operation. Hence the importance of ensuring that the fuel is thoroughly filtered before the pump is reached.

When requesting information regarding the fuel pump, the type and number should be quoted. This can be obtained from a plate fitted to the fuel pump body.

Where service is required, this should be obtained from the fuel pump manufacturer's agents.

For removal and refitting of the fuel injection pump, see Page J.4.

Maximum No Load Speed Setting

When fitting a replacement fuel pump, it should be noted that the governor maximum speed is set to a nominal figure only and final adjustment must be made on the engine.

The maximum no load speed can be established from the fuel pump setting code. A typical code might be for instance, LH31/900/2/2120. It is the last group of figures which indicate the no load speed and in this case, it would be 2120 rev/min (crankshaft speed).

Before fitting a replacement pump to an engine it is important that the setting code on the identification plate on the old pump, be stamped on the identification plate of the pump to be fitted.

The maximum no load speed should be set as follows:

Having firstly run the engine until it has obtained normal running temperature, a suitable tachometer should be brought to register on either the crankshaft or auxiliary equipment (as applicable).

With the engine running at full throttle, take a reading.

Should it be in excess of the figure stamped on the fuel pump, decrease the throttle maximum setting by screwing in the adjusting screw or vice versa if the reverse applies, until the tachometer reading coincides with the correct setting.

The adjustment should now be locked and sealed by authorised personnel and the tachometer reading checked to ensure that it is still correct.

Fuel Pipes

No two of the pressure pipes from the fuel pump to the atomisers are alike. Keep this in mind when replacing.

Examine the nipples which will be found on each end of these pipes.

If the union nuts at any time have been overtightened, the nipples may have been damaged. If so, leakage will result and the complete fuel pipe will have to be replaced.

In this connection, bear in mind that the working pressure which these joints must sustain is several thousand pounds per square inch. Only a perfect joint is satisfactory.

Offer up the pipe to the fuel pump and atomiser unions to check that the pipe fits square at both ends. Do not fit one end and then bend the pipe to square it with the other union.

When fitting the pipe, tighten the unions alternately a little at a time, first one end and then the other.

If the pipe is square to the unions at each end as described above, no force will be needed to make a good joint. No force should be used.

Use only a standard open ended spanner.

If the union is tightened excessively, the nipple may be damaged. The same danger exists if the pipe is not square to and central with the union.

The correct torque for the high pressure fuel pipe unions is 15 lbf ft (2,1 kgf m) or 20 Nm.

When changing an atomiser, always remove the pipe entirely. Never undo only one end leaving the other tight. Never bend the pipe.

Atomisers

Each atomiser consists of a steel body, held to the cylinder head by means of a flange and two studs.

A one piece collar type dust seal is fitted on earlier engines but later engines have an improved two piece arrangement which consists of a soft rubber sealing ring or sleeve and a rigid spacer spacer which presses down onto the rubber sealing ring.

The joint between the atomiser and cylinder head is made by a special copper washer between the lower face of the nozzle cap nut and the recess in the cylinder head.

When preparing to fit the atomiser into place in the cylinder head, care should be taken that only this type of copper washer is used to make this joint. The recess in the cylinder head, the faces of the copper washer and the corresponding face on the nozzle holder cap nut should be perfectly clean if a leakproof joint is to result.

It is advisable to fit a new joint washer and rubber dust seal assembly when the atomiser is replaced, after having been removed for any reason.

Ensure that the old washer and dust seal has been removed from the cylinder head or atomiser.

This joint washer should be an easy, but not loose fit for the atomiser nozzle and it is because this is such an important feature that only washers specially made for the purpose should be used and none other. Ensure the plastic spacer, where used, is fitted above the rubber dust seal.

The atomiser can now be fitted in place, care being taken to see that it is an easy fit in the cylinder head and on the holding down studs, so that it can be placed down on the copper joint without force of any kind. The nuts on the flange should then be tightened down evenly in order to prevent the atomiser nozzle being canted and so "nipped" in the cylinder head. This is very important since any unevenness in tightening down may cause distortion of the atomiser nozzle, resulting in its failure and will most certainly result in blowby.

The correct torque for the atomiser securing nuts is 12 lbf ft (1,7 kgf m) or 16 Nm.

Maintenance

Atomisers should be taken out for examination at regular intervals. How long this interval should be is difficult to advise, because of the different conditions under which engines operate.

When combustion conditions in the engine are good and the fuel tank and filtering system are maintained in first class order, it is often sufficient if the atomisers are tested yearly. For detailed times refer to Preventive Maintenance page E.3.

It is no use taking atomisers out for attention unless an atomiser testing pump is available or spare atomisers are at hand for substitution.

The nearer the ideals of good fitting with adequate cooling and absolutely clean fuel are realised, the less attention the atomisers will need, and so the longer their efficient life. In this connection, since there is no other item upon which the performance of the engine depends so much, it pays the user handsomely to see that the engine never runs with any of its atomisers out of order.

Troubles in Service

The first symptoms of atomiser trouble usually fall under one or more of the following headings :

1. Misfiring.
2. Knocking in one (or more) cylinders.
3. Engine overheating.
4. Loss of power.
5. Smoky exhaust (black).
6. Increased fuel consumption

Often the particular atomiser or atomisers causing trouble may be determined by releasing the pipe union nut on each atomiser in turn, with the engine running at a fast 'Tick-over.' This will prevent fuel being pumped through the nozzle to the engine cylinder, thereby altering the engine revolutions. If after slackening a pipe union nut, the engine revolutions remain constant, this denotes a faulty atomiser.

After stopping the engine the nuts from the flange of the doubtful atomiser should be removed and the complete unit withdrawn from the cylinder head and turned round, atomiser nozzle outwards, 'unwiped' on its pipe, and the unions re-tightened.

After slackening the unions of the other atomiser pipes (to avoid the possibility of the engine starting), the engine should be turned until the nozzle sprays into the air, when it will be seen at once if the spray is in order. If the spray is unduly 'wet' or 'streaky' or obviously to one side, or the atomiser 'dribbles,' the complete unit should be replaced, the faulty unit being securely wrapped in clean grease-proof paper or rag for attention on the maintenance bench.

Great care should be taken to prevent the hand from getting into contact with the spray, as the working pressure will cause the oil to penetrate the skin with ease.

Atomiser Pressures

The relevant pressures can be ascertained by reference to the atomiser code letters and the table given in Section B. The code letters are either stamped on the atomiser tab washer or on the atomiser body.

The "Setting Pressure" is the pressure at which a new atomiser is set and is slightly high to allow for the initial fall off of pressure that occurs in the first few hours of operation. The "Working Pressure" is the pressure at which a used atomiser can be checked.

After reconditioning, the atomiser should be set to the Setting Pressure if a new spring has been fitted or to the Working Pressure if the existing parts have been refitted.

No attempt should be made to service or reset the pressure of an atomiser unless the proper equipment is available.

When renewing atomisers, reference should be made to the appropriate Parts List to ensure fitment of the correct type.

AIR CLEANERS

The time period for cleaning the air cleaner depends on operating conditions. Therefore, under extremely dusty conditions, the time limit recommended for cleaning should be decreased.

If not already fitted, you should consider the fitting of an 18 in water gauge RESTRICTION INDICATOR in the air trunking between the air filter and the engine induction manifold. It indicates by means of a visual signal when the air filter element needs servicing.

The correct maintenance of the cleaner will greatly assist in extending the life of the engine.

Oil Bath Cleaner

In the oil bath cleaner (Figs. N.10 and N.11), the incoming air impinges upon the surface of the oil carried in a reservoir in the lower part of the casing.

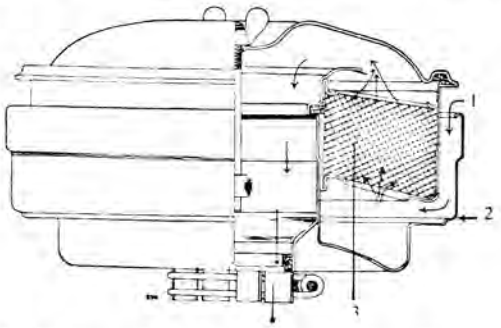
As a result of this, particles of foreign matter are carried into the oil by their own momentum and there trapped.

The air next passes through a steel wire element before reaching the induction manifold and in that element are deposited any other particles of foreign matter which still remain in the air after its contact with the oil.

Maintenance

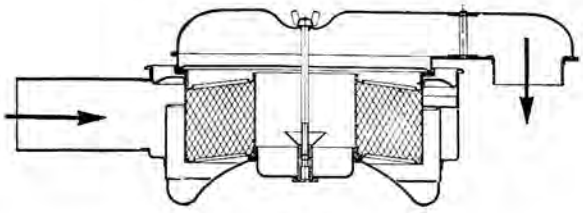
Examine, replenish oil, and clean in accordance with Preventive Maintenance Section C.

At the stipulated intervals, remove the top cover and lift out element, wash in cleaning fluid and allow to drain. Empty oil out of outer case and scrape out accumulated sludge. Wash outer case with cleaning fluid and refill with engine oil



1. Air Flow. 2. Oil Level. 3. Wire Element.

N.10



N.11

to level indicated (do not overfill). Replace element and top cover, care being taken to see that the joint ring is in good condition, and is sealing.

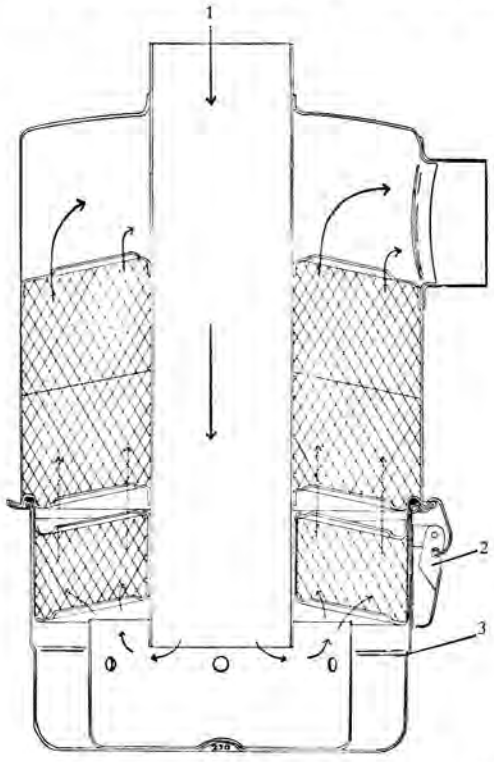
Tractor Type

In the tractor type oil bath cleaner, the air is drawn through the intake pipe and down through the centre of the filter to the oil bath. Here the air impinges upon the surface of the oil and particles of foreign matter are carried into the oil by their own momentum and trapped. The air then passes up the sides of the cleaner through the wire maze and out through the connection at the top (see Fig. N.12).

Maintenance

Examine, replenish oil and clean in accordance with Preventive Maintenance Section C.

Remove oil container and empty out the oil.



N.12

1. Air Inlet. 2. Clip. 3. Oil Level.

Scrape out all the accumulated sludge and thoroughly wash in cleaning fluid.

Inspect the wire gauze and if necessary, remove the cleaner body from the installation and wash in cleaning fluid. Allow to drain before re-assembly.

Refill oil container to the level indicated (do not overfill) and re-assemble to cleaner.

DRY TYPE TWO STAGE "CYCLOPAC"

The dust bowl (Fig. N.13) collects the heavier particles which are thrown out by the centrifuge path of the air. This dust enters the bowl by the slot in the baffle plate. The level of dust in the bowl must not be allowed to reach to within half an inch of the slot in the baffle plate. For cleaning purposes, the assembly should be removed from the engine.

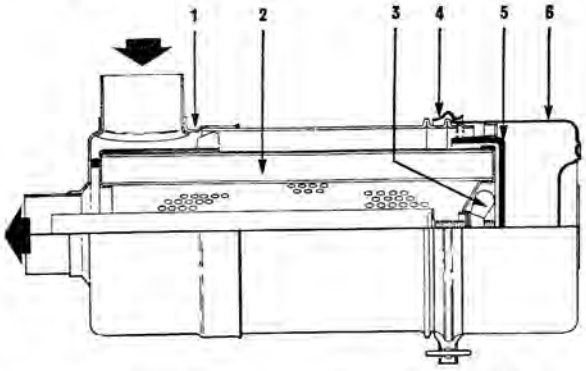
With horizontal installations the slot in the baffle is located at the top.

Remove the dust bowl by releasing the pinch screw clamp. Remove the baffle from the interior of the dust cup by lifting it out, which gives access to the dust for removal. The element can be removed by releasing the wing nut.

Renew the element or clean by back flow air pressure no more than 100 lbf/in² (7,03 kgf/cm²) or 690 kN/m² or washing in a non foaming detergent as recommended by the air cleaner manufacturers. Allow the element to soak for at least ten minutes and then gently agitate. Rinse the element with clean water and allow to dry. Do not use oven heat.

WARNING. There is a danger that some of the dust remaining in the element after it is washed will be pulled through into the engine if the element is replaced in a wet condition. The reason for this is that the water acts as a carrier for the dust.

Inspect the element by placing a bright light in its centre. Any pin holes, thin spots or ruptures render the element unfit for further use. This cleaning procedure reduces the effective life of the element.



1. Body Assembly.
2. Element Assembly.
3. Nut and Gasket Assembly.
4. Clamp Assembly.
5. Baffle Skirt.
6. Dust Bowl.

N.13

With all dry type elements, they should be replaced after six cleanings or once a year, whichever is the soonest.

Never use petrol (gasoline) for cleaning.

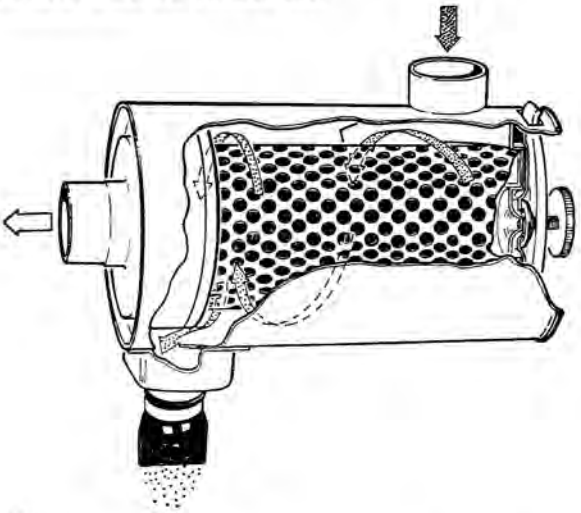
DRY TYPE TWO STAGE "CYCLONE"

The Automatic Dust Ejector should always be kept clean and the lips of the rubber ejector checked to see that they close but do not adhere together.

To service the element (Fig. N.14), unscrew the clamping screw and remove the element retaining strip. Remove the seal plate (if fitted) and element.

If the element is contaminated by dry dust, clean by carefully tapping by hand or by directing low pressure compressed air on to the clean side of the element. If the element is contaminated by oil or soot, it can be cleaned by washing in a suitable non-foaming detergent. After washing, rinse out thoroughly by directing clean water to clean air side of element and allow to dry—do not oven dry.

Inspect cleaned element by placing a bright light inside and looking through element. Any thin spots, pin holes or other damage will render the element unfit for further use.



N.14

The element should be changed after six detergent washes or annually, whichever occurs first. Clean the inside of the filter body and dry thoroughly. Inspect joints, hoses and clips and renew where necessary.

Re-assemble filter ensuring that all joints are leak proof.

SECTION P
Flywheel and Flywheel Housing

Alignment of the Flywheel Housing and Flywheel

It is most important that the flywheel housing be correctly aligned with the crankshaft. Misalignment may give rise to difficulty in changing gear, etc. If the housing has been removed, the greatest care must be taken on replacement to ensure accuracy of alignment. The appropriate procedure is as follows :—

See that the face of both the rear of the cylinder block and flywheel housing are perfectly clean and free from burrs.

Refit the housing and tighten the setscrews but not overtight so as to allow adjustment.

Alignment of the Flywheel Housing Bore

Secure the base of a "clock" gauge to the flange of the crankshaft.

Set the needle of the gauge to the inside of the flywheel housing bore.

Turn the crankshaft and check that this is truly central. The housing is adjusted until it is central.

For convenience in turning the engine it is advisable to release (but not remove) the nuts holding the atomisers in place.

The flywheel housing bore should be truly central with the crankshaft within the limits given in the table (total indicator reading).

Alignment of the Flywheel Housing Face

With the base of the "clock gauge" still bolted to the crankshaft flange, adjust the "clock" so as to set the needle against the vertical machined face of the flywheel housing, and, again turning the crankshaft, check that this face is perpendicular to the crankshaft axis. When carrying out this check, the crankshaft should be pressed forward to take up end float.

This facing should be within the limits given in the table (total indicator reading) of being truly at right angles to the crankshaft axis.

All adjustments to bring the flywheel housing within the limits must be on the flywheel housing and under NO CONDITIONS must the rear of the cylinder block be interfered with.

When the housing is properly aligned to the above limits, tighten the securing setscrews evenly.

Ream the dowel holes and fit the correct length and size dowels.

Fitting Flywheel and Checking Alignment

With the flywheel and crankshaft flange perfectly clean and free from burrs and with two suitable guide studs fitted in the crankshaft flange, position the flywheel on the crankshaft.

Insert the setscrews complete with locking plates into the flywheel holes and tighten evenly.

Secure the base of the "clock" gauge to the flywheel housing. With the flywheel at top centre, set the needle of the gauge on the periphery at T.D.C.

Turn the crankshaft and check the clock, the flywheel should run truly within 0.012 in (0,30 mm) (total indicator reading).

With the base of the "clock" gauge still bolted to the flywheel housing, adjust the clock so as to set the needle against the vertical machined face of the flywheel.

Again turn the crankshaft and check the clock. The flywheel should be truly at right angles to the crankshaft axis within the limit of 0.001 in (0,025 mm) per inch (25 mm) of flywheel radius from the crankshaft axis to the clock gauge plunger (total indicator reading).

When the flywheel has been checked for correct alignment, lock setscrews with locking plates.

Finally grease the spigot ball race if fitted.

LIMITS FOR FLYWHEEL HOUSING ALIGNMENT

Housing Dia.	
Up to 14½ in (362 mm)	0.006 in (0,15 mm)
Over 14½ in (362 mm) to 20⅛ in (511 mm)	0.008 in (0,20 mm)
Over 20⅛ in (511 mm) to 25½ in (648 mm)	0.010 in (0,25 mm)
Over 25½ in (648 mm) to 31 in (789 mm)	0.012 in (0,30 mm)

SECTION Q
Alternator, Dynamo & Starter Motor

ALTERNATOR
18ACR, 23ACR, A115/45 and LR Series

Precautions

The diodes in the alternator function as one-way valves and the transistors in the regulator/control box operate as fast switches. Both are accurate and sensitive.

They do not wear out and seldom require adjustment, but because they are sensitive to voltage changes and high temperature, the following precautions are vital to prevent them from being destroyed.

(a) DO NOT disconnect the battery whilst the engine is running. This will cause a voltage surge in the alternator charging system that will immediately ruin the diodes or transistors.

(b) DO NOT disconnect a lead without first stopping the engine and turning all electrical switches to the off position.

(c) DO NOT cause a short circuit by connecting leads to incorrect terminals. Always identify a lead to its correct terminal. A short circuit or wrong connection giving reverse polarity will immediately and permanently ruin transistors or diodes.

(d) DO NOT connect a battery into the system without checking for correct polarity and voltage.

(e) DO NOT "flash" connections to check for current flow. No matter how brief the contact the transistors may be ruined.

Maintenance

The alternator charging system will normally require very little attention, but it should be kept free from build-up of dirt, and a check made if it fails to keep the battery charged.

(a) Regularly inspect the driving belts for wear and correct tension. It is important to ensure that all belts on a multiple belt drive have equal tension and are each carrying their share of the load. Slack belts will wear rapidly and cause slip which will not drive the alternator at the required speed. Drive belts which are too tight impose severe side thrust on the alternator bearings and shorten their life. Periodically ensure that the alternator is correctly aligned to the drive.

(b) Do not replace faulty belts individually in a multi-belt system. A complete matched set of drive belts must always be used.

(c) Keep the alternator clean with a cloth moistened in kerosene or cleaning fluids. Ensure that ventilation slots and air spaces are clear and unobstructed.

(d) Remove any dirt accumulated on the regulator/control box housing, and ensure that cooling air can pass freely over the casing.

Testing the Alternator in Position

First check the driving belt for condition and tension. The nominal hot outputs at 6,000 rev/min (alternator speed) are as follows :—

15ACR — 28A	A115/45 — 45A
16ACR — 34A	LR135 — 35A
17ACR — 36A	LR150 — 50A
17ACR (De-rated) — 25A	
18ACR — 45A	
23ACR — 55A	

The de-rated 17ACR alternator is used on some applications operating under extremely dusty conditions.

These figures may be exceeded slightly when the alternator is running cold. To avoid misleading results, the following test procedure should therefore be carried out with the alternator running as near as possible to its normal operating temperature.

Alternator Output Test with Regulator Inoperative

Withdraw the two part connector from the alternator, remove the moulded cover (secured by two screws) and earth the regulator green lead or connector strip to frame.

With the remainder of the test circuit connected as for the alternator output test, start the engine and again run the alternator up to 6,000 rev/min until the ammeter shows an output current of less than 10 amperes. The voltmeter should then give a reading of 13,6 — 14,4 volts. Any appreciable deviation from this (regulating) voltage means that the regulator is not functioning properly and must be replaced.

If the foregoing tests show the alternator and regulator to be satisfactorily performing, disconnect the test circuit and reconnect the alternator terminal connector. Now connect a low range voltmeter between the positive terminal of the alternator (the moulded terminal connector is open ended to facilitate this) and the positive terminal of the battery. Switch on battery load (headlights, etc.), start the engine and increase speed until the alternator runs at approximately 6,000 rev/min.

Transfer the voltmeter connections to the negative terminals of the alternator and battery and again note the meter reading.

If the reading exceeds 0.5 volt on the positive side or 0.25 volt on the negative side, there is a high resistance in the charging circuit which must be traced and remedied.

DYNAMO
Model C40A

The C40A dynamo is a shunt-wound two-pole two-brush machine arranged to work in conjunction with a compensated voltage control regulator unit. A ball bearing supports the armature at the driving end and a porous bronze bush at the rear supports the commutator end.

The output of the dynamo is controlled by the regulator unit and is dependent on the state of charge of the battery and the loading of the electrical equipment in use. When the battery is in a low state of charge, the dynamo gives a high output, whereas if the battery is fully charged, the dynamo gives only sufficient output to keep the battery in good condition without any possibility of overcharging. An increase in output is given to balance the current taken by lamps and other accessories when in use.

When fitting a new control box, it is important to use only an authorised replacement. An incorrect replacement can result in damage to the dynamo.

Routine Maintenance

(a) **Lubrication**

Every 250 running hours, inject a few drops of high quality S.A.E. 30 engine oil into the hole marked "OIL" at the commutator end bearing housing.

(b) **Inspection of Brush Gear**

Every 1,000 running hours, the dynamo should be removed from the engine and the brushgear inspected by a competent electrician.

(c) **Belt Adjustment**

Occasionally inspect the dynamo driving belt, and if necessary adjust to take up any slackness by turning the dynamo on its mounting. Care should be taken to avoid overtightening the belt (see Page M.1). At the same time check the dynamo pulley securing nut tightness. Pull to a torque of 15/20 lbf ft (2,1/2,7 kgf m) — 20/27 Nm.

Servicing — Testing in Position to Locate Fault in Charging Circuit

1. Inspect the driving belt and adjust if necessary.
2. Check the connections on the commutator end bracket. The larger connector carries the main dynamo output, the smaller connector the field current.
3. Switch off all lights and accessories, take off the cables from the terminals of the dynamo and connect the two terminals with a short length of wire.
4. Start the engine and set to run at normal idling speed.
5. Clip the negative lead of a moving coil type voltmeter, calibrated 0/20 volts, to one dynamo terminal and the positive lead to a good earthing point on the yoke.
6. Gradually increase the engine speed, when the voltmeter reading should rise rapidly and without fluctuation. Do not allow the voltmeter reading to reach 20 volts, and do not race the engine in an attempt to increase the voltage. It is sufficient to run the dynamo up to a speed of 1,000 rev/min. If the voltage does not rise rapidly and without fluctuation the unit must be dismantled for internal examination. Excessive sparking at the commutator in the above test indicates a defective armature which should be replaced.

STARTER MOTOR
Model 2M113, M45G, S12-84 and S12-85

General

This starter motor is a four-pole, four-brush earth return machine with series-parallel connected field coils.

A solenoid-operated pre-engaged drive assembly is carried on an extension of the armature shaft.

The main features of this type of drive are as follows :—

(a) Positive pinion engagement preventing the pinion being thrown out of mesh whilst starting.

(b) Dual-purpose plate-clutch incorporated in the drive assembly giving over-speed and overload protection.

(c) Self-indexing pinion to ensure smooth engagement between the pinion and the flywheel teeth before the starter motor begins to rotate.

(d) Armature braking system to ensure rapid return to rest when the starter button is released.

Routine Maintenance

(a) The starter motor requires no routine maintenance beyond the occasional inspection of the electrical connection which must be clean and tight, the brush gear, and the commutator.

(b) After the starter motor has been in service for some time, remove the starter motor from the engine and submit it to a thorough bench inspection.

1. Brush wear (this is a fair indication of the amount of work done). Renew brushes worn to, or approaching $\frac{5}{16}$ in (7,9 mm) in length.

2. Brush spring tension. Correct tension is 30/40 oz (0,85/1,13 kg). Renew springs of tension has dropped below 25 oz (0,71 kg).

3. Skim commutator if it is pitted or badly worn.

4. Check bearings for excessive side play of armature shaft.

5. Check pinion movement.

6. Clean and lubricate the indented bearing inside the pionion sleeve using Shell SB2628 grease for temperate or cold climates or Shell Retinex for hot climates.

7. Clean and lubricate the indented bronze bearing in the intermediate bracket. Use Ragosine 'Molypad' Molybdenised non-creep oil for this purpose.

Servicing — Testing in Position

Switch on the lamps. If the vehicle is not equipped with lighting, then connect a 0/20 voltmeter across the battery terminals before proceeding. Operate the starter control and watch for the following symptoms :—

1. The lamps dim (or voltmeter reading drops to about 6 volts), and the motor does not crank the engine.

   Check battery (must be at least half-charged) and battery lugs (clean and a good earth connection).

2. The lamps do not dim, the voltmeter reading remains steady at about 12 volts, and the motor does not crank the engine.

   Connect voltmeter from solenoid terminal 'BAT', and starter yoke, operate starter; No volts indicated.

   (a) Poor lug connections at battery.

   (b) Bad earth connection.

   (c) Broken starter lead, battery to starter.

   Full volts i.e., 12/14 volts indicated.

   (a) Faulty solenoid switch.

   (b) Open circuit in starter — check brushes.

SECTION R
Marine Engines

The D3.152 Marine engine with a rating of 39 shp at 2,000 rev/min for commercial and heavy duty commercial, follows a similar design to the other series of D3.152 diesel engines in as much as the majority of component parts may be serviced in accordance with the instructions given in the appropriate sections of this manual.

Certain auxiliaries are however employed with marine engines and it is for the servicing of these items that the following instructions are given.

De-Rating for Altitude

This is not usually necessary for marine engines, but where engines are called upon to operate in rarified atmospheres occasioned by altitude, such engines should be de-rated in accordance with the instructions given on page B.2.

Preventive Maintenance

KEEP ENGINE CLEAN.

DAILY OR EVERY 8 HOURS WHICHEVER OCCURS FIRST

Check oil level in engine sump, gearbox and reduction gear.

Check cooling water circulation.

Check lubricating oil pressure.

EVERY 50 HOURS

Top up batteries with distilled water (where fitted).

Check fresh water pump/dynamo belt adjustment.

EVERY 100 HOURS

Oil chain drive and bushes of hand starting equipment and pawl assembly at rear of crankshaft pulley (when fitted).

Grease hand start ratchet (when fitted).

Clean fuel oil pre-filter (where fitted).

Examine and clean air inlet cleaner gauze.

Check valve clearances and oil flow to rockers.

Examine and clean sea water inlet strainer (where fitted).

Examine engine holding down bolts.

EVERY 250 HOURS OR FOUR MONTHS WHICHEVER OCCURS FIRST

Renew element in lubricating oil filter.

Change lubricating oil in engine sump.

EVERY 500 HOURS OR TWELVE MONTHS WHICHEVER OCCURS FIRST

Clean and check atomisers.

Clean out breather pipe on cylinder head cover.

Examine heat exchanger (where fitted) and oil coolers for scale formation and descale where necessary.

Renew element in final fuel filter.

Change oil in gearbox and reduction gear.

EVERY 2500 HOURS

Check accessory equipment, alternator, starter motor, etc.

Starting Equipment

Provision is made for hand starting or alternatively, 12 volt electrical equipment is employed. The starter motor is mounted on the starboard side of the engine, the starter pinion engaging with the starter ring on the flywheel at the aft end of the engine.

Where hand starting equipment is employed, this should be used in conjunction with the decompressor lever on the cylinder head cover.

For electrical starting, instructions are given on page C.1.

Sump Drain Pump

With some engines, it may not be possible to drain the sump by means of the sump drain plug. In order to overcome this difficulty, a hand operated sump drain pump can be fitted to the starboard side of the engine. The sump capacity is 11 pints — 6,3 litres — 6.6 US quarts. The total engine capacity is 12.5 pints — 7,1 litres — 7.5 US quarts.

Gearbox

Two types of gearbox can be found on D3.152 marine engines, namely the Borg Warner 71CR with 2.1 : 1 or 2.9 : 1 reduction and the PRM 140S with 2 : 1 reduction. Both boxes are hydraulically operated.

To Remove the Gearbox

Uncouple the propellor shaft from the gearbox outlet flange and move clear of box. Uncouple oil pipes between oil cooler and gearbox.

Remove setscrews securing gearbox to flywheel housing.

The gearbox can then be removed by withdrawing it to the rear.

The driving plate connecting the gearbox to the flywheel can now be removed. It should be noted that if either the flywheel or flywheel housing is removed, then it must be accurately aligned on replacement in accordance with the instructions given on Page P.1.

Replacement of the gearbox is the reverse procedure to removal.

Water Circulation

The engine may be so arranged as to accomodate one of the following cooling systems.

Direct Cooling System

With this type of circulation, a water pump employing a rubber impeller is used. Raw water is drawn up to the engine oil cooler and then through the gearbox oil cooler to the water pump. From the pump, it is fed to the cylinder block. The coolant leaves the engine at the front of the cylinder head where it is finally led overboard.

Indirect Cooling System (Heat Exchanger)

This type of cooling system utilised in conjunction with a heat exchanger incorporates two separate water pumps.

A rubber impeller type pump is used to circulate the raw water, the coolant being drawn up through the gearbox oil cooler to the pump. Coolant is then fed to the heat exchanger and finally to the engine oil cooler from where it is discharged overboard.

The circulation of the coolant in the fresh water side of the closed circuit system is effected by means of a centrifugal pump belt driven from the crankshaft pulley. Water is pumped from the heat exchanger by this pump to the cylinder block and then flows back from the front of the cylinder head to the heat exchanger. The closed water circuit capacity is 14 pints — 8 litres — 8.8 US quarts.

Centrifugal Type Water Pump

Since the centrifugal water pump employed on D3.152 marine engines incorporating indirect cooling is identical with the pump fitted on D3.152 engines in general, maintenance for this type pump may be obtained by referring to Section M.

Note: The centrifugal type pump does not require greasing as the bearings are treated with a special grease before assembly.

Rubber Impeller Type Water Pump

This type of pump is gear driven inasmuch as a gear wheel attached to the impeller drive shaft is in constant mesh with the camshaft gear wheel, the pump itself being mounted on the starboard side of the engine above the dynamo.

Removal and Dismantling of Rubber Impeller Pump

First disconnect water inlet and outlet hose connections. The pump may then be detached by removing the setscrews that secure it to the engine timing case.

To dismantle the pump, proceed as follows :—

Remove rear end cover.

Remove impeller.

Remove wear plate.

With the front bearing cover removed, a suitable press can be used to press out the impeller shaft (from the impeller end) together with the front bearing, leaving the drive gear wheel loose in its housing.

The cam in the impeller housing may then be detached by removing the single securing setscrew.

Remove rubber seal in impeller housing.

Remove rubber 'O' ring.

Remove distance pieces.

The driving gear wheel housing and impeller shaft rear bearing may then be removed from the pump body.

Finally remove front rubber seal.

To re-assemble the water pump, the reverse order of the above procedure should be adopted, care being taken when replacing the rubber impeller, that the blades all lay in the same direction relative to the rotation of the pump, i.e. blades trailing.

When re-assembling, ensure that the rubber impeller is coated with a layer of water resisting grease. It should also be noted that, if necessary, the impeller may be dismantled without removing the water pump.

When replacing the cam fitted in the impeller housing, be certain to treat the entire top surface, rear face and securing setscrew hole with a suitable jointing compound. Note :— This cam will go into place one way only.

With the assembled pump fitted to the engine, backlash between pump and camshaft gears should be 0.003 in to 0.009 in (0,08 to 0,23 mm). To achieve this in production, two joints may have been fitted between the pump gear wheel housing and engine timing case. Should this be so, ensure that both joints or two new joints are replaced when refitting the pump.

If the engine is to be withdrawn from service for any length of time, it will be necessary to effect lubrication of the rubber impeller at the commencement of the storage period. This may be achieved by removing the end cover and placing Marfak 2HD grease between the vanes of the impeller.

Oil Coolers

Oil coolers are providing on D3.152 marine engines to maintain lubricating oil and gearbox oil at correct temperatures.

To Remove Oil Cooler

Uncouple inlet and outlet moulded rubber water connections to the oil coolers.

Remove inlet and outlet oil pipes (gearbox oil cooler only).

Remove gearbox cooler by unscrewing the two nuts on the ends of the oil cooler securing clamp.

Remove engine oil cooler by unscrewing bolts securing it to the cooler/filter adaptor.

Replacement of the oil coolers is effected by reversing the above procedures.

Cleaning the Oil Cooler Tube Stack

Under normal circumstances, the oil coolers will require little attention providing the seawater strainer is efficient and is kept clean.

After a lengthy period of service, it may be necessary to clean the tube stacks and this may be effected in a similar manner to that described later for the heat exchanger.

Note : Oil cooler tube stacks are integral with the outer casing and are not removable.

To Dismantle Heat Exchanger

When dismantling, it is best to proceed as follows with the heat exchanger still fitted to the engine.

Remove the two raw water pipes from their respective end covers.

Remove the two end covers by unscrewing the securing setscrews.

Remove the "O" seals from each end of the tube stack.

The tube stack can now be removed from the heat exchanger casing.

Cleaning the Heat Exchanger Tube Stack

If the tube stack appears to be badly fouled up, the best method of cleaning is to use non caustic crysalline solvents approved by the manufacturers.

Usually, the fresh water side, i.e., the outside of the tubes are relatively clean as these are on the closed water circuit. The inside of these tubes which have the raw water (sea water) passing through them are more likely to require cleaning. If these are not badly scaled enough to require the solution treatment described above, they can be cleaned by pushing a length of $\frac{1}{8}$ in (3,2 mm) diameter steel rod down the tubes to dislodge all foreign matter. It is important to note that when carrying out this exercise, the rod should be pushed through the tubes in the opposite direction to that in which the water flows. Do not use undue force to push the rod through the tubes.

The other components of the assembly should be cleaned before re-assembly and as these have no hidden features, no special instructions are considered necessary.

Re-assembling the Heat Exchanger

The re-assembly of the heat exchanger is the reverse procedure to dismantling. If the "O" rings appear to be badly worn or deformed, then they should be renewed.

LUBRICATING OILS

Lubricating oils should meet the requirements of the U.S. Ordnance Specifications MIL-L-46152 or MIL-L-2104C. It is not advisable to use a lubricating oil to the MIL-L-2104C specification for the first 25 hours in service. The lubricating oils for use in Perkins Diesel engines should have a **minimum** Viscosity Index of 80.

Some of these oils are listed below and on next page but any other oils which meet these specifications are also suitable.

MIL-L-46152 Oils

Company	Brand	S.A.E. Designation		
		0°F (-18°C) to 30°F (-1°C)	30°F (-1°C) to 80°F (27°C)	Over 80°F (27°C)
B.P. Ltd.	Vanellus M	10W	20W	30
	Vanellus M		20W/50	20W/50
Castrol Ltd.	Castrol/Deusol CRX	10W	20	30
	Castrol/Deusol CRX	10W/30	10W/30	10W/30
	Castrol/Deusol CRX		20W/50	20W/50
	Deusol RX Super		20W/40	20W/40
A. Duckham & Co. Ltd.	Fleetol HDX	10	20	30
	Fleetol Multi V		20W/50	20W/50
	Fleetol Multilite	10W/30	10W/30	10W/30
	Farmadcol HDX		20	30
	Hypergrade		15W/50	15W/50
	Fleetmaster		15W/40	15W/40
Esso Petroleum Co. Ltd.	Essolube XD-3	10W	20W	30
	Essolube XD-3		15W/40	15W/40
Mobil Oil Co. Ltd.	Delvac 1200 Series	1210	1220	1230
	Delvac Special	10W/30	10W/30	10W/30
Shell	Rimula X	10W	20W/20	30
	Rimula X	10W/30	10W/30	10W/30
	Rimula X		15W/40	15W/40
	Rimula X		20W/40	20W/40
	Rotella TX	10W	20W/20	30
	Rotella TX		20W/40	20W/40
Total Oil Co. Ltd.	Total Super HD		20W/20	30
	Total HD2-M	10W/30	20W/40	20W/50
	Total HD3-C (Rubia S)	10W	20W/20	30
	Total HD3-C (Rubia TM)		15W/40	15W/40
	Total Universal Tractor Oil (Multagri)		20W/30	20W/30
	Total Super Universal Tractor Oil (Multagri TM)		20W/30	20W/30

MIL-L-2104C Oils

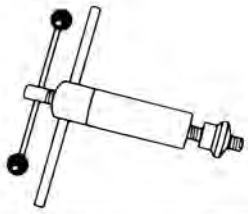
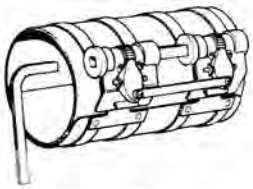
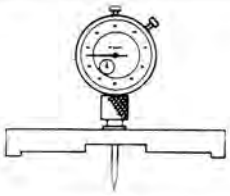
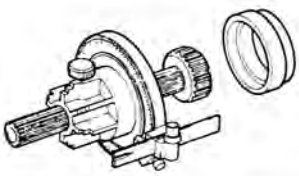
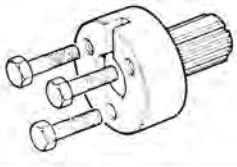
Company	Brand	S.A.E. Designation		
		0°F (-18°C) to 30°F (-1°C)	30°F (-1°C) to 80°F (27°C)	Over 80°F (27°C)
B.P. Ltd.	Vanellus C3	10W	20W/20	30
Castrol Ltd.	Castrol/Deusol CRD	10W	20	30
	Deusol RX Super		20W/40	20W/40
	Agricastrol HDD	10W	20	30
	Agricastrol MP		20W/30	20W/30
	Agricastrol MP		20W/40	20W/40
A. Duckham & Co. Ltd.	Fleetol 3	3/10	3/20	3/30
	Farmadcol 3	3/10	3/20	3/30
	Hypergrade		15W/50	15W/50
	Fleetmaster		15W/40	15W/40
Esso Petroleum Co. Ltd.	Essolube D-3HP	10W	20W	30
	Essolube XD-3	10W	20W	30
	Essolube XD-3		15W/40	15W/40
Mobil Oil Co. Ltd.	Delvac 1300 Series	1310	1320	1330
Shell	Rimula CT	10W	20W/20	30
	Rimula X	10W	20W/20	30
	Rimula X	10W/30	10W/30	10W/30
	Rimula X		15W/40	15W/40
	Rimula X		20W/40	20W/40
	Rotella TX	10W	20W/20	30
	Rotella TX		20W/40	20W/40
Total Oil Co. Ltd.	Total HD3-C (Rubia S)	10W	20W/20	30
	Total HD3-C (Rubia TM)		15W/40	15W/40
	Total Super Universal Tractor Oil (Multagri TM)		20W/30	20W/30

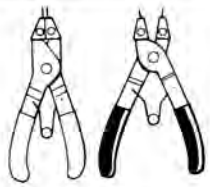
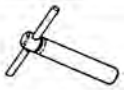
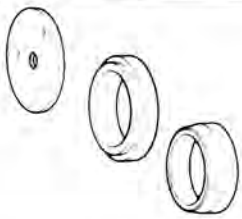
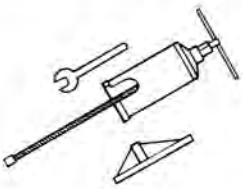
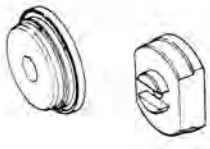
Where oils to the MIL-L-46152 or MIL-L-2104C specifications are not available, then oils to the previous specification MIL-L-2104B may continue to be used providing they give satisfactory service.

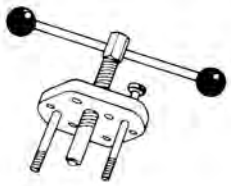
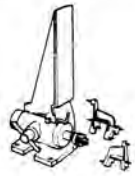
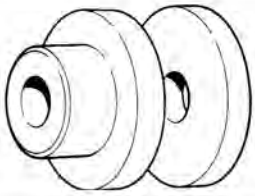
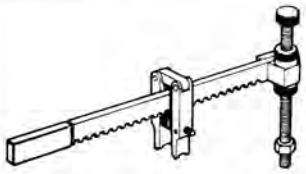
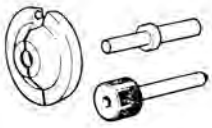
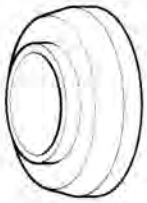
The above specifications are subject to alteration without notice.

APPROVED SERVICE TOOLS

The majority of these tools are available from your Perkins Distributor. Those marked with an asterisk are available from V. L. Churchill & Co. Ltd., Daventry, Northamptonshire, NN11 4NF, England.

	Tool No.	Description
	21825026	VALVE GUIDE REMOVER AND REPLACER (MAIN TOOL)– EARLY ENGINES ONLY
	21825027	ADAPTOR FOR 21825026 A pair of puller bars fitted with knurled nuts. Suitable for $\frac{5}{16}$" and $\frac{3}{8}$" guides.
	21825029	ADAPTOR FOR 21825026 A 15 mm ($^{19}/_{32}$ in) distance piece used to replace exhaust valve guides to a set height.
	21825018	PISTON RING SQUEEZER
	21825019	PISTON HEIGHT AND VALVE DEPTH GAUGE A simple method of quickly checking piston height.
	MS.67B*	UNIVERSAL TIMING GAUGE For checking fuel injection pump timing.
	PD.67B-1*	ADAPTOR FOR MS.67B For use with mechanically governed fuel injection pump.
	21825064	ADJUSTABLE VALVE SEAT CUTTERS (for 45° seats) Set comprises six cutters, a pilot for 45° and 30° cutters and a handle.

	Tool No.	Description
	21825017	CIRCLIP PLIERS (internal and external)
	MS.76*	VALVE SEAT CUTTER HANDLE FOR 21825068 AND 21825069 (Also included in 45° Valve Seat Cutter Set 21825064).
	MS.150-8*	VALVE SEAT CUTTER PILOT FOR 21825068 AND 21825069 (Also included in 45° Valve Seat Cutter Set 21825064)
	21825068	EXHAUST VALVE SEAT CUTTER *Used with handle MS.76 and pilot MS.150-8.
	21825069	INLET VALVE SEAT CUTTER *Used with handle MS.76 and pilot MS.150-8.
	PD.145C*	CRANKSHAFT REAR OIL SEAL REPLACER ADAPTOR (LIP TYPE SEAL)
	21825052	CYLINDER LINER REMOVER/ REPLACER (MAIN TOOL) For Field Service replacement of single liners. Not advised for complete overhaul. For this work use adaptors with a hydraulic ram unit.
	21825053	CYLINDER LINER REMOVER/INSTALLER RATCHET WRENCH For use with 21825052 where space is limited.
	21825054	ADAPTORS FOR 21825052 Suitable for cylinders of 3.6" dia. Removal and replacement.

	Tool No.	Description
	21825006	BASIC PULLER Cruciform head with multiple holes at different centres complete with adaptors.
	335*	CON ROD JIG & 336 MASTER ARBOR
	336-102*	ARBOR ADAPTOR Used with 335.
	21825020	VALVE SPRING COMPRESSOR
	21825023	ADAPTOR FOR 21825020
	MF.200-26	WATER PUMP OVERHAUL KIT Used with 370 Taper Base and Press.
	PD.159*	TIMING CASE COVER CENTRALISING TOOL

EXAMPLES OF SERVICE FACILITIES

Service Publications

The following Service Literature may be purchased through your local Perkins Distributor.

Workshop Manuals

Workshop Data

Operators Handbooks

Turbocharger Service Instructions

Valve Seat Inserting and Cylinder Head Skimming

Simms Fuel Pump Workshop Manual

Crankshaft Regrinding

Fault Finding Guide

Etcetera

Service Instruction

PETERBOROUGH

Apply to Product Education Department for details.

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POWERPART Consumable Products

To give assistance in the correct operation, service and maintenance of your engine and machine, Perkins Engines Ltd., have made available the products shown below.

The instructions for the use of each product are given on the outside of each container.

These products are available from your Perkins distributor.

POWERPART Antifreeze
Gives corrosion protection and also a more efficient coolant in hot conditions. See Page C.5.

POWERPART Lay-Up 1
A diesel fuel additive for protection against corrosion. See Page C.4.

POWERPART Lay-Up 2
Gives inside protection to the engine and other closed systems. See Page C.4.

POWERPART Lay-Up 3
Gives outside protection to any metal parts. See Page C.5.

POWERPART De-Icer
To remove frost.

POWERPART Silent Spray
Silicone lubrication to lubricate and prevent noise from hinges, slide doors, etc.

POWERPART Damp Displacer
To make electrical equipment dry and to give future protection.

POWERPART Hylomar
Universal sealing compound to seal joints.

POWERPART Hylosil
Silicone rubber sealant to prevent leakage.

POWERPART Impact Adhesive
To keep joints in position during installation and other general attachment purposes.

POWERPART Locking Agent.
Used to securely install fasteners, sleeves, etc.

POWERPART Solvent
To thoroughly clean metal faces before assembly.

This publication is produced by the Technical Publications Department of Perkins Engines Limited and every endeavour is made to ensure that the information contained in this Manual is correct at the date of publication but, due to continuous developments, the manufacturers reserve the right to make alterations without notice.

USE ONLY GENUINE PERKINS PARTS

TO ENSURE YOU OBTAIN THE BEST RESULTS FROM YOUR ENGINE AND TO SAFEGUARD YOUR OWN GUARANTEE, FIT ONLY GENUINE PERKINS PARTS. THESE ARE READILY OBTAINABLE THROUGHOUT THE WORLD.

Perkins
WORKSHOP MANUAL

All information in this workshop manual is substantially correct at the time of printing but may be altered subsequently by the Company.

Perkins Engines

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